



DEPARTMENT OF COMMERCE

Bureau of Industry and Security

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Publication of a Report on the Effect of Imports of Vanadium on the National Security: An Investigation Conducted Under Section 232 of the Trade Expansion Act of 1962, as Amended

AGENCY: Bureau of Industry and Security, Commerce.

ACTION: Publication of a Report.

SUMMARY: The Bureau of Industry and Security (BIS) in this notice is publishing a report that summarizes the findings of an investigation conducted by the U.S. Department of Commerce (the “Department”) pursuant to Section 232 of the Trade Expansion Act of 1962, as amended (“Section 232”), into the effect of imports of vanadium on the national security of the United States. This report was completed on February 22, 2021 and posted on the BIS website in July 2021. BIS has not published the appendices to the report in this notification of report findings, but they are available online at the BIS website, along with the rest of the report (*see* the ADDRESSES section).

DATES: The report was completed on February 22, 2021. The report was posted on the BIS website in July 2021.

ADDRESSES: The full report, including the appendices to the report, are available online at <https://www.bis.doc.gov/index.php/documents/section-232-investigations/2793-vanadium-section-232-report-public-with-appendices/file>

FOR FURTHER INFORMATION CONTACT: Kevin Coyne, Industrial Studies Division, Bureau of Industry and Security, U.S. Department of Commerce, (202) 482-5481, Vanadium232@bis.doc.gov. Unless otherwise protected by law, any information received from the public during the course of this investigation may be made publicly available. For more

information about the Section 232 program, including the regulations and the text of previous investigations, please see www.bis.doc.gov/232.

THE EFFECT OF IMPORTS OF VANADIUM ON THE NATIONAL SECURITY

**AN INVESTIGATION CONDUCTED UNDER SECTION 232 OF
THE TRADE EXPANSION ACT OF 1962, AS AMENDED**

U.S. Department of Commerce

Bureau of Industry and Security

Office of Technology Evaluation

February 22, 2021

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Prepared by Bureau of Industry and Security

<http://www.bis.doc.gov>

I. Executive Summary

This report summarizes the findings of an investigation conducted by the U.S. Department of Commerce (the “Department”) pursuant to Section 232 of the Trade Expansion Act of 1962, as amended (19 U.S.C. §1862 (“Section 232”)), into the effect of imports of vanadium¹ on the national security of the United States.

Vanadium is used primarily as a strengthening agent in steel products, particularly for products in the construction industry and in tool steel. A smaller but essential use is in titanium

¹ See Figure 1 in Section IV, “Product Scope of the Investigation,” for the vanadium products addressed by this report.

aerospace alloys; military and commercial aircraft are dependent on vanadium-containing titanium products. Vanadium also has significant chemical uses, including as a catalyst in the production of sulfuric acid—itself an important industrial material used in a wide range of production—and in large scale energy storage.

There are three general methods of vanadium production: primary (mining), co-production (from mined ore in concert with steelmaking), and secondary production or recycling (from residues and waste materials). Production generally results in vanadium pentoxide, which can be used in titanium and non-metallurgical uses or further converted, generally to ferrovanadium for incorporation into steel.

There is currently one primary producer of vanadium in the United States (uranium miner Energy Fuels Resources). There are two active secondary producers (the companies that submitted the Section 232 application, AMG Vanadium and U.S. Vanadium), plus a third secondary producer currently modernizing an idle facility (Gladieux Metals Recycling). The primary producer only produced vanadium during one of the last five years and supplied less than 4% of U.S. demand.

Globally, primary and co-production of vanadium is concentrated in four countries: China, Russia, South Africa, and Brazil, with China accounting for over half of global production. Since 1995, the United States has found that imports of ferrovanadium from all major primary producers except Brazil have been sold at less than fair value, resulting in antidumping duties. These duties remain in effect for China and South Africa but have since been revoked for Russia.

Although the United States is reliant on imports of vanadium pentoxide, ferrovanadium, or vanadium-bearing waste products to meet domestic demand, this import reliance will be mitigated by a major expansion being carried out by AMG Vanadium doubling their ferrovanadium production capacity, and the soon-expected completion of Gladieux's renovation, which will reintroduce significant domestic vanadium pentoxide production. In addition, two

mining projects are in the exploratory or permitting phase, potentially adding domestic production capacity as soon as 2023.

The biggest challenge the industry faces is low and volatile vanadium prices. Prices are currently below the levels required for cost effective primary production in the United States, and make it difficult for secondary producers to source feedstock and operate profitably. Adding to producers' woes are the major demand declines due to COVID-19, with demand for vanadium in titanium products hit especially hard as a result of decreased consumption by the aerospace industry.

Given vanadium's almost-exclusive use in concert with steel and titanium, and, as steel and titanium are both considered critical to national security—with their domestic production threatened by imports, as reported in recent Section 232 reports—the Department finds that unilaterally imposing import tariffs or quotas in order to raise the domestic price of vanadium would largely impact domestic steel and titanium industries and would therefore have significant negative effects on the economic and national security of the United States. Cost increases for only domestic steel and titanium producers would put these critical industries, already threatened by low-cost imports, at a further disadvantage relative to foreign producers.

In conducting this investigation, the Secretary of Commerce (the "Secretary") noted the Department's prior investigations under Section 232. This report incorporates the statutory analysis from the Department's 2018 reports on the imports of steel and aluminum² with respect to applying the terms "national defense" and "national security" in a manner that is consistent with the statute and legislative intent.³

² U.S. Department of Commerce. Bureau of Industry and Security. *The Effect of Imports of Steel on the National Security* (Washington, DC: 2018) ("Steel Report") and U.S. Department of Commerce. Bureau of Industry and Security. *The Effect of Imports of Aluminum on the National Security* (Washington, DC: 2018) ("Aluminum Report"). <https://www.bis.doc.gov/index.php/documents/steel/2224-the-effect-of-imports-of-steel-on-the-national-security-with-redactions-20180111/file> <https://www.bis.doc.gov/index.php/documents/aluminum/2223-the-effect-of-imports-of-aluminum-on-the-national-security-with-redactions-20180117/file>

³ Steel Report at 13-14; Aluminum Report at 12-13.

As required by the statute, the Secretary considered all factors set forth in Section 232(d). In particular, the Secretary examined the effect of imports on national security requirements, specifically:

- i. domestic production needed for projected national defense requirements;
- ii. the capacity of domestic industries to meet such requirements;
- iii. existing and anticipated availabilities of the human resources, products, raw materials, and other supplies and services essential to the national defense;
- iv. the requirements of growth of such industries and such supplies and services including the investment, exploration, and development necessary to assure such growth; and
- v. the importation of goods in terms of their quantities, availabilities, character, and use as those affect such industries; and the capacity of the United States to meet national security requirements.

In preparing this report, the Secretary also recognized the close relation of the economic welfare of the United States to its national security. Factors that can compromise the nation's economic welfare include, but are not limited to, the impact of "foreign competition on the economic welfare of individual domestic industries; and any substantial unemployment, decrease in revenues of government, loss of skills, or any other serious effects resulting from the displacement of any domestic products by excessive imports." See 19 U.S.C. § 1862(d). In particular, this report assesses whether vanadium is being imported "in such quantities" and "under such circumstances" as to "threaten to impair the national security."⁴

A. Findings

In conducting the investigation, the Secretary found:

⁴ 19 U.S.C. § 1862(b)(3)(A).

1. Vanadium is essential to U.S. national security

- (a) Vanadium is a critical mineral. The Department of Interior included vanadium on the 2018 List of Critical Minerals required by Executive Order 13817, issued December 20, 2017.⁵ Pursuant to the Executive Order, the list established vanadium as essential to the national security of the United States and found that the absence of a vanadium supply would have significant consequences for the U.S. economy and national security.
- (b) Vanadium is required for national defense systems because of its use in steel and titanium alloys. Vanadium is irreplaceable in key titanium aerospace applications, and many military airframes contain significant amounts of vanadium.
- (c) Vanadium is required for critical infrastructure. A key feature in the high-strength, low-alloy (HSLA) steel products used in the construction industry, as well as in tool steel and high-speed steels, vanadium steel alloys are used throughout U.S. critical infrastructure. In addition, nearly all vanadium-bearing titanium products are used in the critical transportation or defense sectors.
- (d) The vanadium industry has significant effects on other industries critical to U.S. national security. As stated above, vanadium has essential uses in steel and titanium products, and vanadium resources in the United States are often co-located with uranium resources. The Department has recently found that imports in all three of these industries threaten to impair U.S. national security.

2. Imports of vanadium have mixed effects on the economic welfare of the U.S. vanadium industry

⁵ <https://www.usgs.gov/news/interior-releases-2018-s-final-list-35-minerals-deemed-critical-us-national-security-and>

- (a) The United States is presently reliant on imports of vanadium. The only primary vanadium producer in the United States has only produced during one of the last five years, due to low vanadium prices. Domestic secondary producers of vanadium import significant quantities of their feedstock, [TEXT REDACTED].
- (b) U.S. reliance on imports of vanadium is not increasing. Although the country is reliant on imports of vanadium to meet civilian demand, major U.S. producers of ferrovanadium and vanadium pentoxide are in the process of expanding or restarting operations. Given the successful completion of these initiatives, U.S. capacity for ferrovanadium production from vanadium-bearing waste is projected to more than double in 2021, and U.S. capacity for vanadium pentoxide production from vanadium-bearing waste is projected to increase significantly with the re-opening of a secondary production facility. In addition, several domestic mining companies have idle production capacity or are exploring the development of vanadium mines. If domestic vanadium prices rise, or in the event of a national emergency, these companies may increase production and capacity, including through new mines.
- (c) Given continuing low domestic prices, the U.S. vanadium industry may face significant financial challenges. [TEXT REDACTED] However, it is difficult to accurately characterize the financial health of the industry due to recent facility turnover, significant ongoing investments, and recent lack of operational activities.
- (d) Significant resources exist in the United States for primary production. At least three companies have mines that have produced vanadium in the past, and two additional projects are under development.
- (e) Secondary production of vanadium is environmentally beneficial. The vanadium-bearing waste products used in secondary production are classified by the Environmental Protection Agency (EPA) as hazardous waste. However, secondary

production reclaims critical minerals and can divert significant amounts of material from landfills, instead using them in products critical to national defense.

3. Displacement of domestically-produced vanadium by imports affects our internal economy, but is mitigated by ongoing actions

- (a) U.S. production of vanadium is well below domestic demand. Primary and secondary producers produced an annual average of 3.4 million kilograms of vanadium content from 2016 to 2019, while domestic imports of key vanadium products approached 8 million kilograms.
- (b) Domestic production is highly concentrated and limits the capacity available for a national emergency. Just three domestic companies carried out vanadium production in 2019. Additional capacity in the future is not guaranteed, based on low vanadium prices.
- (c) Domestic vanadium production currently requires significant imports of vanadium feedstock, limiting vanadium production capacity available for a national emergency. Only one vanadium producer in recent years has used entirely U.S. origin material, producing the equivalent of 1.4% of total domestic demand since 2016. Secondary producers all use significant levels of foreign feedstock; the United States is unable to satisfy all domestic demand with U.S. sourced material.
- (d) Recent trade actions have successfully mitigated artificially low-priced imports of ferrovanadium. Of the four countries with significant primary production of vanadium, three have been subject to the imposition of antidumping duties on ferrovanadium based on petitions from domestic ferrovanadium producers. In all cases, imports of ferrovanadium from the subject countries fell to close to zero following the imposition of the duties.

- (e) Critical minerals agreements with other countries will help ensure reliable supplies of vanadium. The United States government (USG) released in June 2019 *A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals*, which includes a goal of enhanced international trade and cooperation related to critical minerals.⁶ The United States has subsequently entered into official critical minerals collaborations with Canada and Australia, both of which have significant vanadium resources.

4. Increased global capacity and production of vanadium will further impact the long-term viability of U.S. vanadium production

- (a) China, which accounts for an estimated 50 to 60% of global vanadium production and consumption, possesses an outsized role in determining the global price of vanadium. This concentration of supply and demand means that policy changes in China have significant effects on the global vanadium market, including major price changes in the near past.
- (b) Expansion of low-cost production in countries other than China will place downward pressure on global vanadium prices. Mines in development or exploration in Kazakhstan, Canada, and Australia have the ability to nearly double current global mine production, should they all enter production.
- (c) Downward price pressure may be mitigated by increased demand for steel, titanium, and energy storage. Although currently significantly affected by COVID-19, higher demand in the steel and titanium industries would put upward pressure on vanadium prices. Additionally, annual growth projections for the use of vanadium-based batteries range from 13 to 42% through 2027, which could produce significant additional demand.

⁶ <https://www.commerce.gov/data-and-reports/reports/2019/06/federal-strategy-ensure-secure-and-reliable-supplies-critical-minerals>

- (d) Significant price swings impair the ability of domestic producers to plan and carry out capital expenditures. With vanadium projects taking years to complete and major price swings a common occurrence, companies may be challenged to find financing throughout the course of the development of new vanadium capabilities, or may find their projects not viable once completed.

5. Unilaterally increasing domestic prices of vanadium would harm critical U.S. industries

- (a) Domestic vanadium prices significantly exceeding world prices would disadvantage the U.S. steel industry. The Department's 2018 Section 232 investigation on steel imports found that the steel industry was threatened by imports and in need of assistance to remain viable. As the predominant user of vanadium, the domestic steel industry would face new threats from foreign steel producers if its input costs were significantly higher than those in other countries.
- (b) Domestic vanadium prices significantly exceeding world prices would also harm the U.S. titanium industry, to the benefit of Russian and Chinese producers. The titanium industry is dependent on vanadium because vanadium accounts for between 12 and 14% of the cost of a standard titanium alloy. The U.S. titanium industry is facing significant financial challenges from declines in demand (related to COVID-19), and may not be able to bear additional costs that international competitors do not.

B. Conclusion

Based on these findings, the Secretary concludes that the present quantities and circumstances of vanadium imports do not threaten to impair the national security as defined in Section 232. Although vanadium is critical to national security and the United States is currently dependent on imported sources of vanadium, [TEXT REDACTED] several significant factors, including the health of the U.S. industry, availability of idle domestic resources, existing USG

actions, and the importance of vanadium to competitive steel and titanium industries, indicate that imports of vanadium do not currently threaten to impair national security.

The United States is currently reliant on imports to satisfy demand for vanadium products and is not producing significant amounts of vanadium from U.S.-origin material, but these circumstances are not expected to deteriorate. Two domestic secondary producers are in the process of expanding and/or upgrading their facilities, which will add significantly to the U.S. ability to produce ferrovanadium and vanadium pentoxide from vanadium-bearing waste materials.

Furthermore, in addition to the one existing domestic primary producer, several other companies are in the process of exploring vanadium mining ventures and will be in a position to produce within several years if vanadium prices rise sufficiently. Even if primary production is not feasible at current vanadium prices, the availability of these resources allows for production potential in the event of national emergency. An increase in the production of domestic primary vanadium, expansion of secondary production, and the addition of domestic feedstock for secondary production should mitigate the current levels of reliance on imports.

However, the projected rise in capacity does not necessarily mean that the domestic vanadium industry is healthy. Vanadium prices have a long history of volatility, with prices going through cycles of surging and plunging. The main users of vanadium—the steel and titanium industries—experienced major declines in demand in 2020 related to COVID-19, with the titanium industry particularly challenged by a large decrease in aerospace demand. If vanadium prices fail to rise, some of the capacity under exploration may not turn into production, and one or more secondary producers may face financial difficulty or challenges in sourcing vanadium-bearing feedstock.

Further, the lack of a finding of a threat to national security does not indicate that a healthy domestic vanadium industry is not of vital importance to the United States. While the

Secretary does not believe that imports of vanadium need to be adjusted at this time, there are several steps that can and should be taken to support the domestic vanadium industry and related sectors to ensure safe and reliable sources of vanadium in the event of a national emergency, thereby enhancing and protecting U.S. national security.

C. Recommendations

The Department has identified several actions that would help to ensure reliable domestic sources of vanadium and lessen the potential for imports to threaten national security. These actions are not intended to be exhaustive or exclusive; the Secretary recommends pursuing all proposed actions.

Recommendation 1 – Expansion of the National Defense Stockpile to Include High Purity Vanadium Pentoxide

The USG should support domestic vanadium production and ensure a source of vanadium in the event of national emergency by re-adding vanadium pentoxide to the National Defense Stockpile. Vanadium pentoxide was part of the stockpile until 1997; the stockpile held 6,200 tons of contained vanadium⁷ in 1965 and had a goal of 7,000 tons though it held just 651 tons prior to the decision to reduce the target level to zero in 1993, following the end of the cold war.⁸ Using high purity vanadium pentoxide—suitable for use in titanium alloys or chemical uses as well as conversion into ferrovanadium for use in the steel industry—would ensure vanadium held in the stockpile could be used for any necessary product in the event of national security.

National Defense Stockpile goals were initially set to ensure sufficient product to support one year's demand for the entire country but were later narrowed to focus on defense-specific needs, primarily due to funding constraints. Given the importance of vanadium and other critical

⁷ Vanadium is generally reported in terms of “contained vanadium”, or the weight of only the vanadium portion of a vanadium compound. Vanadium represents 56% of the weight of vanadium pentoxide.

⁸ USGS Vanadium Mineral Commodity Summaries. <https://www.usgs.gov/centers/nmic/vanadium-statistics-and-information>

minerals to the economy, the economic and national security of the United States would be better served by pursuing stockpile goals that support national security beyond defense-specific requirements. The re-addition of vanadium to the stockpile would require authorization and funding from Congress.

The Department recommends that the size of the proposed vanadium addition to the stockpile should be based on three benchmarks: defense system requirements, broader national security requirements, and total domestic demand. As discussed above, defense system requirements may conservatively amount to 273 metric tons of vanadium content per year; this inventory level would be worth approximately \$10.5 million based on average vanadium pentoxide prices since 2016.⁹ Critical infrastructure requirements add an estimated 4,527 tons per year, resulting in a minimum stockpile goal based on total national security requirements of 4,800 tons of contained vanadium, at a cost of \$184.8 million. Finally, total domestic apparent consumption (including defense and critical infrastructure needs) averaged 8,590 tons of contained vanadium annually from 2016 to 2019. Establishing a stockpile goal at this level, sufficient to meet all domestic demand, would be valued at \$330.6 million.

Beyond the minimum stockpile level, the Secretary further recommends that the stockpile of vanadium pentoxide be authorized to expand in size during periods of unusually low prices (with purchases made from domestic producers), while remaining unchanged or shrinking during periods of higher-than-average prices. This policy would help mitigate the large historic price swings that have caused significant financial distress and impeded capital investment in the domestic vanadium industry while helping to regulate domestic prices.

Implementing this policy would require legislative changes to the Strategic and Critical Materials Stockpiling Act (50 U.S.C. §98, et seq.) (Stockpiling Act). While the mitigation of critical mineral price swings and the purchase of critical minerals from domestic producers at a

⁹ Average price per pound vanadium pentoxide from 2016-2019 of \$9.80, based on data from USGS: <https://pubs.usgs.gov/periodicals/mcs2020/mcs2020-vanadium.pdf>

premium when prices are unusually low serves the interest of national defense, the Stockpiling Act requires that the stockpile “not be used for economic or budgetary purposes,” which may present a challenge in allowing the stockpile to exceed minimum defense needs based on prices. Allowing the stockpile to be used for economic purposes if such actions support the health and competitiveness of affected industries would help enhance U.S. national security.

As an additional potential benefit, once the vanadium holdings in the National Defense Stockpile are established, they could—with the authorization of Congress and in cooperation with the Department of Energy—be used without cost to support another sector: large scale energy storage. As noted above, a potential new use for vanadium is in vanadium redox flow batteries, which have the advantage of using vanadium in both parts of the electrolyte, eliminating the risk of cross-contamination and allowing for the vanadium to be re-claimed from the batteries at a low cost with minimal yield loss¹⁰.

With vanadium accounting for approximately 30% of the cost of a vanadium redox flow battery and initial battery cost reductions needed to enable larger scale use, the USG could reduce the costs of the stockpile and support the energy storage sector by leasing a portion of the stockpile to be managed by vanadium redox flow battery companies, on condition of the leased vanadium being immediately reclaimable in the event of a national emergency. Given restrictions on transfers to and from the stockpile, this use of material in the stockpile would require either a legislative change to the Stockpiling Act or the designation of the leased material as still being part of the stockpile despite being used for energy storage.

Recommendation 2 – Recycling Promotion

The Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals

(Federal Strategy) identifies an available, on-demand supply of critical minerals as “essential to

¹⁰ Vanitec estimates cost of conversion from leachate to vanadium pentoxide at \$1 per pound vanadium pentoxide with a 95% yield. <http://www.vanitec.org/vanadium/ESC-Meetings>

the economic prosperity and national defense of the United States.”¹¹ The Federal Strategy recommends the support of recycling and reprocessing of critical minerals, including vanadium. Given that nearly all vanadium production in the United States is performed through recycling, the USG should support the vanadium industry through USG-wide actions to promote the recycling of materials containing critical minerals.

A 2002 EPA analysis, carried out in support of the May 8, 2002 final rule on the identification and listing of spent catalysts as hazardous waste, showed that in 1999, just 55% of spent catalyst was recycled, in large part because the cost of recycling was estimated to be three times that of landfill disposal.¹² Bringing the recycling of vanadium-bearing wastes generated in the United States to or near 100% has the potential to greatly expand the availability of vanadium products of domestic origin. Such recycling will occur naturally with higher vanadium prices, as refiners typically receive a metals credit from vanadium producers based on vanadium sale price, but can also be encouraged through the consideration of recycling tax deductions or credits as well as EPA review of their regulatory authority governing disposal of hazardous waste.

For example, additional information submitted by industry to the Department reported that the 2020 International Maritime Organization’s (IMO) regulation requiring the reduction of allowable levels of sulfur in maritime fuels from 3.5% to 0.5% has increased refinery catalyst use, which is expected to result in increased availability of spent catalyst used to produce vanadium.¹³ Similar regulations in the United States would support both the EPA mission to protect human health and the environment and domestic production of critical minerals.

Recommendation 3 – Continue USG Actions to Support Critical Minerals

¹¹ https://www.commerce.gov/sites/default/files/2020-01/Critical_Minerals_Strategy_Final.pdf

¹² 67 FR 30811 and <https://archive.epa.gov/epawaste/hazard/web/pdf/backdoc.pdf>

¹³ <https://ig9we1q348z124x3t10meupc-wpengine.netdna-ssl.com/wp-content/uploads/AMG-Annual-Report-Web-FINAL.pdf>

Many of the challenges domestic vanadium producers face are not unique to vanadium; with this investigation the Department has completed Section 232 investigations on four of the 35 critical minerals. While the specific challenges of each critical mineral are distinct, many industrial trends are similar and broad solutions may be more effective than individual targeting. There are several ongoing and proposed U.S. government actions that support the domestic supply of critical minerals. Continuing to pursue these actions will provide necessary support to the domestic vanadium industry as well as to the broader critical minerals sector.

Among the key actions that will enable strong domestic critical minerals industries are Executive Order 13817 and the resulting Federal Strategy, Executive Order 13953 (*Addressing the Threat to the Domestic Supply Chain From Reliance on Critical Minerals From Foreign Adversaries and Supporting the Domestic Mining and Processing Industries*), proposals from the USG Nuclear Fuel Working Group, work being carried out by the Titanium Sponge Working Group, and legislative action to support domestic production of critical minerals. Since the list of suitable substitutions for vanadium in steel and certain chemical processes includes other minerals on the critical minerals list (including manganese, niobium, titanium, tungsten, and platinum), actions to support production of critical minerals as a whole would also help to address domestic vanadium supply challenges.

The Federal Strategy, developed pursuant to Executive Order 13817, was announced in June 2019, with six calls to action containing 24 goals and 61 recommended actions that federal agencies should pursue to improve the availability of critical minerals and their downstream supply chains in the United States to help reduce the country's vulnerability to supply chain disruptions. Many of the identified goals of the Federal Strategy are consistent with the findings and recommendations of this investigation, including:

- (a) support for downstream materials production capacity;
- (b) enhancing the National Defense Stockpile's ability to meet military as well as civilian requirements;

- (c) securing access to critical minerals through trade and investment with allies;
- (d) identifying methods to encourage secondary use of critical minerals; and
- (e) streamlining permit processes for critical mineral projects.

The President issued Executive Order 13953, “Addressing the Threat to the Domestic Supply Chain From Reliance on Critical Minerals From Foreign Adversaries and Supporting the Domestic Mining and Processing Industries,” (E.O. 13953), in September 2020. The Order identifies the need to ensure a consistent supply of critical minerals and declares a national emergency to reduce the threat posed by the country’s undue reliance on critical minerals from foreign adversaries. Many of the actions taken pursuant to E.O. 13953 will support the domestic vanadium industry, particularly vanadium mining.

In addition to Executive actions, there have recently been several legislative proposals that would provide support for vanadium and other critical minerals. Examples include H.R. 8143 (also known as the Reclaiming American Rare Earths (RARE) Act) and S. 3694 (the Onshoring Rare Earths (ORE) Act of 2020). Both bills as written restrict the definition of critical minerals to a subset of those identified by the Department of Interior in response to E.O. 13817, and need to be expanded to include vanadium and other critical minerals, but otherwise have features of significant value to the domestic vanadium industry. In addition to allowing a tax deduction for investments in property used for mining, reclaiming, or recycling critical materials, these bills would support the function of critical minerals in the broader economy by providing grants or allowing tax deductions for critical minerals extracted in the United States. In addition to expanding the bills to include vanadium (as noted above), in order to provide the most value to the country, the Department recommends that any legislation should ensure that extraction incentives include recycling and reclamation.

Finally, the Department’s Section 232 investigations into imports of Uranium and Titanium sponge resulted in the creation of USG working groups tasked with developing recommendations additional to those made in each report. Given the significant intersections

between the vanadium industry and the uranium and titanium industries, the implementation of the working groups' recommendations will support the vanadium industry as well.

II. Legal Framework

A. Section 232 Requirements

Section 232 of the Trade Expansion Act of 1962, as amended, provides the Secretary with the authority to conduct investigations to determine the effect on the national security of the United States of imports of any article. It authorizes the Secretary to conduct an investigation if requested by the head of any department or agency, upon application of an interested party, or upon his own motion. *See* 19 U.S.C. § 1862(b)(1)(A).

Section 232 directs the Secretary to submit to the President a report with recommendations for “action or inaction under this section” and requires the Secretary to advise the President if any article “is being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security.” *See* 19 U.S.C. § 1862(b)(3)(A).

Section 232(d) directs the Secretary and the President to, in light of the requirements of national security and without excluding other relevant factors, give consideration to the domestic production needed for projected national defense requirements and the capacity of the United States to meet national security requirements. *See* 19 U.S.C. § 1862(d).

Section 232(d) also directs the Secretary and the President to “recognize the close relation of the economic welfare of the Nation to our national security, and ...take into consideration the impact of foreign competition on the economic welfare of individual domestic industries” by examining whether any substantial unemployment, decrease in revenues of government, loss of skills or investment, or other serious effects resulting from the displacement

of any domestic products by excessive imports, or other factors, results in a “weakening of our internal economy” that may impair the national security.¹⁴ *See* 19 U.S.C. § 1862(d).

Once an investigation has been initiated, Section 232 mandates that the Secretary provide notice to the Secretary of Defense that such an investigation has been initiated. Section 232 also requires the Secretary to do the following:

- (1) “Consult with the Secretary of Defense regarding the methodological and policy questions raised in [the] investigation;”
- (2) “Seek information and advice from, and consult with, appropriate officers of the United States;” and
- (3) “If it is appropriate and after reasonable notice, hold public hearings or otherwise afford interested parties an opportunity to present information and advice relevant to such investigation.”¹⁵ *See* 19 U.S.C. § 1862(b)(2)(A)(i)-(iii).

As detailed in the report, all of the requirements set forth above have been satisfied.

In conducting the investigation, Section 232 permits the Secretary to request that the Secretary of Defense provide an assessment of the defense requirements of the article that is the subject of the investigation. *See* 19 U.S.C. § 1862(b)(2)(B).

Upon completion of a Section 232 investigation, the Secretary is required to submit a report to the President no later than 270 days after the date on which the investigation was initiated. *See* 19 U.S.C. § 1862(b)(3)(A). The report must:

¹⁴ An investigation under Section 232 looks at excessive imports for their threat to the national security, rather than looking at unfair trade practices as in an antidumping investigation.

¹⁵ Department regulations (i) set forth additional authority and specific procedures for such input from interested parties, *see* 15 C.F.R. §§ 705.7 and 705.8, and (ii) provide that the Secretary may vary or dispense with those procedures “in emergency situations, or when in the judgment of the Department, national security interests require it.” *Id.*, § 705.9.

- (1) Set forth “the findings of such investigation with respect to the effect of the importation of such article in such quantities or under such circumstances upon the national security;”
- (2) Set forth, “based on such findings, the recommendations of the Secretary for action or inaction under this section;” and
- (3) “If the Secretary finds that such article is being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security . . . so advise the President.” *See* 19 U.S.C. § 1862(b)(3)(A).

All unclassified and non-proprietary portions of the report submitted by the Secretary to the President must be published.

Within 90 days after receiving a report in which the Secretary finds that an article is being imported into the United States in such quantities or under such circumstances as to threaten to impair the national security, the President shall:

- (1) “Determine whether the President concurs with the finding of the Secretary”; and
- (2) “If the President concurs, determine the nature and duration of the action that, in the judgment of the President, must be taken to adjust the imports of the article and its derivatives so that such imports will not threaten to impair the national security” (*see* 19 U.S.C. § 1862(c)(1)(A)).

B. Discussion

While Section 232 does not specifically define “national security,” both Section 232, and the implementing regulations at 15 C.F.R. Part 705, contain non-exclusive lists of factors that the Secretary must consider in evaluating the effect of imports on the national security. Congress in

Section 232 explicitly determined that “national security” includes, but is not limited to, “national defense” requirements. *See* 19 U.S.C. § 1862(d)).

In a 2001 report, the Department determined that “national defense” includes both the defense of the United States directly, and the “ability to project military capabilities globally.”¹⁶ The Department also concluded in 2001 that, “in addition to the satisfaction of national defense requirements, the term “national security” can be interpreted more broadly to include the general security and welfare of certain industries, beyond those necessary to satisfy national defense requirements, which are critical to the minimum operations of the economy and government.” The Department called these “critical industries.”¹⁷ While this report uses these reasonable interpretations of “national defense” and “national security,” it uses the more recent 16 critical infrastructure sectors identified in Presidential Policy Directive 21¹⁸ instead of the 28 industry sectors identified in the 2001 Report.¹⁹

Section 232 directs the Secretary to determine whether imports of any article are being made “in such quantities” or “under such circumstances” that those imports “threaten to impair the national security.” *See* 19 U.S.C. § 1862(b)(3)(A). The statutory construction makes clear that either the quantities or the circumstances, standing alone, may be sufficient to support an affirmative finding. The two may also be considered together, particularly when the circumstances act to prolong or magnify the impact of the quantities being imported.

The statute does not define a threshold for when “such quantities” of imports are sufficient to threaten to impair the national security, nor does it define the “circumstances” that might qualify.

Similarly, the statute does not require a finding that the quantities or circumstances are impairing the national security. Instead, the threshold question under Section 232 is whether the

¹⁶ Department of Commerce, Bureau of Export Administration; *The Effects of Imports of Iron Ore and Semi-Finished Steel on the National Security*; Oct. 2001 (“2001 Iron and Steel Report”) at 5.

¹⁷ *Id.*

¹⁸ Presidential Policy Directive 21; *Critical Infrastructure Security and Resilience*; February 12, 2013 (“PPD-21”).

¹⁹ *See Op. Cit.* at 16.

quantities or circumstances “threaten to impair the national security.” *See* 19 U.S.C.

§ 1862(b)(3)(A). This makes evident that Congress expected an affirmative finding under Section 232 before an actual impairment of the national security.²⁰

Section 232(d) contains a list of factors for the Secretary to consider in determining if imports “threaten to impair the national security”²¹ of the United States, and this list is mirrored in the implementing regulations. *See* 19 U.S.C. §1862(d) and 15 C.F.R. § 705.4. Congress was careful to note twice in Section 232(d) that the list provided, while mandatory, is not exclusive.²² Congress’ illustrative list is focused on the ability of the United States to maintain the domestic capacity to provide the articles in question as needed to maintain the national security of the United States.²³ Congress broke the list of factors into two equal parts using two separate sentences. The first sentence focuses directly on “national defense” requirements, thus making clear that “national defense” is a subset of the broader term “national security.” The second sentence focuses on the broader economy and expressly directs that the Secretary and the

²⁰ The 2001 Iron and Steel Report used the phrase “fundamentally threaten to impair” when discussing how imports may threaten to impair national security. *See* 2001 Iron and Steel Report at 7 and 37. Because the term “fundamentally” is not included in the statutory text and could be perceived as establishing a higher threshold, the Secretary expressly does not use the qualifier in this report. The statutory threshold in Section 232(b)(3)(A) is unambiguously “threaten to impair” and the Secretary adopts that threshold without qualification. 19 U.S.C. § 1862(b)(3)(A).

²¹ 19 U.S.C. § 1862(b)(3)(A).

²² *See* 19 U.S.C. § 1862(d) (“the Secretary and the President shall, in light of the requirements of national security and without excluding other relevant factors...” and “serious effects resulting from the displacement of any domestic products by excessive imports shall be considered, without excluding other factors...”).

²³ This reading is supported by Congressional findings in other statutes. *See, e.g.*, 15 U.S.C. § 271(a)(1) (“The future well-being of the United States economy depends on a strong manufacturing base...”) and 50 U.S.C. § 4502(a) (“Congress finds that – (1) the security of the United States is dependent on the ability of the domestic industrial base to supply materials and services... (2)(C) to provide for the protection and restoration of domestic critical infrastructure operations under emergency conditions... (3)... the national defense preparedness effort of the United States government requires – (C) the development of domestic productive capacity to meet – (ii) unique technological requirements... (7) much of the industrial capacity that is relied upon by the United States Government for military production and other national defense purposes is deeply and directly influenced by – (A) the overall competitiveness of the industrial economy of the United States; and (B) the ability of industries in the United States, in general, to produce internationally competitive products and operate profitably while maintaining adequate research and development to preserve competitiveness with respect to military and civilian production; and (8) the inability of industries in the United States, especially smaller subcontractors and suppliers, to provide vital parts and components and other materials would impair the ability to sustain the Armed Forces of the United States in combat for longer than a short period.”).

President “shall recognize the close relation of the economic welfare of the Nation to our national security.”²⁴ *See* 19 U.S.C. § 1862(d).

In addition to “national defense” requirements, two of the factors listed in the second sentence of Section 232(d) are particularly relevant in this investigation. Both are directed at how “such quantities” of imports threaten to impair national security *See* 19 U.S.C. § 1862(b)(3)(A). In administering Section 232, the Secretary and the President are required to “take into consideration the impact of foreign competition on the economic welfare of individual domestic industries” and any “serious effects resulting from the displacement of any domestic products by excessive imports” in “determining whether such weakening of our internal economy may impair the national security.” *See* 19 U.S.C. § 1862(d).

After careful examination of the facts in this investigation, the Secretary has determined that the present quantities and circumstance of vanadium imports do not threaten to impair the national security, as defined in Section 232. Although vanadium is critical to national security and the United States is currently dependent on imported sources of vanadium, several significant factors, including the health of the U.S. industry, availability of idle domestic resources, existing USG actions, and the importance of vanadium to competitive domestic steel and titanium industries, indicate that imports of vanadium do not threaten to impair national security.

III. Investigative Process

A. Initiation of Investigation

On November 19, 2019, AMG Vanadium LLC and U.S. Vanadium LLC (hereafter “Applicants”) petitioned the Secretary to conduct an investigation under Section 232 of the

²⁴ *Accord* 50 U.S.C. § 4502(a).

Trade Expansion Act of 1962, as amended, to determine the effect of imports of vanadium on the national security.

Upon receipt of the petition, the Department carefully reviewed the material facts outlined in the petition and held initial discussions internally as well as with the Department of Defense. Legal counsel at the Department also carefully reviewed the petition to ensure it met the requirements of the Section 232 statute and the implementing regulations. Subsequently, on May 28, 2020, the Department accepted the petition and initiated the investigation. Pursuant to Section 232(b)(1)(b), the Department notified the U.S. Department of Defense of its intent to conduct an investigation in a May 21, 2020 letter from Secretary Ross to then Secretary of Defense, Mark Esper (*see* Appendix A).

B. Public Comments

On June 3, 2020, the Department published a Federal Register Notice (*see* Appendix B - Federal Register, Vol. 85, No. 107, 34179) announcing the initiation of an investigation to determine the effect of imports of vanadium on the national security. The notice also announced the opening of the public comment period. In the notice, the Department invited interested parties to submit written comments, opinions, data, information, or advice relevant to the criteria listed in Section 705.4 of the National Security Industrial Base Regulations (15 C.F.R. § 705.4) as they affect the requirements of national security, including the following:

- (a) Quantity of the articles subject to the investigation and other circumstances related to the importation of such articles;
- (b) Domestic production capacity needed for these articles to meet projected national defense requirements;
- (c) The capacity of domestic industries to meet projected national defense requirements;
- (d) Existing and anticipated availability of human resources, products, raw materials, production equipment, facilities, and other supplies and services essential to the national defense;

- (e) Growth requirements of domestic industries needed to meet national defense requirements and the supplies and services including the investment, exploration and development necessary to assure such growth;
- (f) The impact of foreign competition on the economic welfare of any domestic industry essential to our national security;
- (g) The displacement of any domestic products causing substantial unemployment, decrease in the revenues of government, loss of investment or specialized skills and productive capacity, or other serious effects;
- (h) Relevant factors that are causing or will cause a weakening of our national economy; and
- (i) Any other relevant factors

The initial public comment period ended on July 20, 2020, and was followed by a public comment rebuttal period, which ended on August 17, 2020. Following requests from the general public, the Department published a copy of the Applicants' petition on September 25, 2020 and opened an additional public comment period, which ended October 9, 2020.

The Department received 32 responsive submissions during the initial public comment period, which were posted on Regulations.gov for public review and rebuttal filing. The Department received 47 rebuttal filings from 11 commenters, which were posted on Regulations.gov for public review. During the additional comment period, the Department received and posted seven comments on Regulations.gov.

Parties who submitted comments included representatives of the domestic vanadium production industry, representatives of the domestic uranium industry, representatives of the foreign vanadium production industry, consumers of vanadium products from the steel, titanium, and energy storage industries, as well as representatives of foreign governments, and other concerned organizations. The Department carefully reviewed all of the public comments and

factored them into the investigative process. The public comments of key stakeholders are summarized in Appendix C, which also includes a link to the docket number (BIS-2020-0002) under which all public comments can be viewed in full on Regulations.gov.

C. Information Gathering and Data Collection Activities

Due to the limited number of firms engaged in the U.S. vanadium industry, it was determined that a public hearing was not necessary to conduct a comprehensive investigation. In lieu of holding a public hearing on this investigation, the Department issued a separate mandatory survey (*see* Appendix E) to participants in the vanadium production and distribution industry, collecting both qualitative and quantitative information. The survey was sent to 34 companies with the ability to develop, produce, or distribute vanadium products for use in the United States. Eight of these companies did not have locations in the United States, and were invited to participate in the survey on a voluntary basis.

The surveys provided a method for respondents to disclose confidential and non-public information. These surveys, to which response was mandatory for domestic respondents, were conducted using statutory authority pursuant to Section 705 of the Defense Production Act of 1950, as amended (50 U.S.C. § 4555) (DPA), and collected detailed information concerning factors such as imports/exports, production, capacity utilization, employment, operating status, global competition, and financial information. The resulting data provided the Department with detailed industry information that was otherwise not publicly available and was needed to effectively conduct analysis for this investigation.

The Department deems the information furnished in the survey responses confidential and will not publish or disclose it except in accordance with Section 705 of the DPA, which prohibits the publication or disclosure of this information unless the President determines that the withholding of such information is contrary to the interest of the national defense. Therefore, the information submitted to the Department in response to the survey will not be shared with any non-government entity other than in aggregate form.

D. Interagency Consultation

The Department consulted with the Department of Defense's Office of Industrial Policy and the Defense Logistics Agency, regarding methodological and policy questions that arose during the investigation. The Department also consulted with other U.S. Government agencies with expertise and information regarding the vanadium industry including the Department of Energy, the Department of State, the Office of the United States Trade Representative, the Department of Homeland Security, the Environmental Protection Agency, and the Department of Interior's U.S. Geological Survey.

IV. Product Scope of Investigation

The scope of this investigation defined vanadium products at the Harmonized Tariff Schedule of the United States (HTS) 10-digit level. The nine product categories and related HTS codes covered by this report are shown below in Figure 1.

| Figure 1: Vanadium Product Scope of the Investigation | |
|---|------------------------------|
| Heading/Subheading/Product | 10 Digit HTS Code |
| Vanadium Oxides | 2825.30.0010 2825.30.0050 |
| Ferrovandium | 7202.92.0000 |
| Vanadium Carbides | 2849.90.5000 |
| Vanadates | 2841.90.1000 |
| Vanadium Ore and Concentrates | 2615.90.6090 |
| Ash and Residues Containing Vanadium | 2620.40.0030 2620.99.1000 |
| Vanadium Sulfate | 2833.29.3000 |
| Vanadium Hydrides, Nitrides, Azides, Silicides, and Borides | 2850.00.2000 |
| Vanadium, Unwrought and Wrought | 8112.92.7000 8112.99.2000 |
| Source: United States International Trade Commission and U.S. Department of Commerce, Bureau of Industry and Security | |

In order to ensure that the full vanadium production process was covered, these HTS codes include vanadium products as well as vanadium-containing precursors. Vanadium is most commonly traded as vanadium oxides (typically vanadium pentoxide (V_2O_5)) and ferrovanadium (FeV), with usage in steelmaking accounting for the vast majority of consumption.

Detailed information was collected in the Department's survey responses from U.S. vanadium producers regarding vanadium-containing products. Data throughout this report is presented, to the extent possible, in kilograms or metric tons of contained vanadium. For example, vanadium pentoxide is 56% vanadium by weight, while vanadium content in ferrovanadium varies from 35% to 80%(though is typically consistent for a given producer). Prices of vanadium pentoxide, in keeping with industry conventions, are quoted in U.S. Dollars per pound of vanadium pentoxide (not vanadium content).

This report also considers the state of industries that depend on vanadium, in particular the U.S. titanium and steel industries, both of which manufacture materials that the U.S. government has recognized as critical to national security. As the Department is aware that the principal customers of vanadium are steel producers, understanding potential ramifications on the U.S. steel industry was necessary to ensure a complete analysis of the effect of vanadium imports on the national security. Vanadium is also a key element in the production of titanium alloy products that are critical to national security, with titanium sponge the subject of a recent Section 232 investigation and the focus of an ongoing working group. The Secretary's recommendations consider the interdependence of the U.S. vanadium industry and these crucial U.S. industries.

V. Background on U.S. Vanadium Industry

A. Vanadium Production

Vanadium is produced through three general methods: primary production (mining), co-production (from mined ore in concert with steelmaking), and secondary production (from

residues and waste materials). Nearly all vanadium in the United States is generated through secondary production, with some vanadium mining occurring together with uranium mining in sandstone-hosted deposits.

Currently there is one primary producer of vanadium in the United States: Energy Fuels Resources (USA), Inc. (Energy Fuels). Although Energy Fuels’ vanadium production activities are dependent on vanadium market prices, the company also may produce vanadium as a by-product of uranium mining, depending on uranium market prices. The United States had no primary production of vanadium from 2014 to 2018; Energy Fuels restarted production in 2019 following a surge in vanadium prices.²⁵ The company produced approximately 1.8 million pounds of vanadium pentoxide in 2019—equivalent to approximately 460,000 kilograms of contained vanadium—prior to ceasing production “due to weak vanadium market conditions.”²⁶ Energy Fuels’ production accounted for under 1% of estimated worldwide primary- and co-production in 2019, with the remainder produced in four countries: China, Russia, South Africa, and Brazil (see Figure 2).

| Figure 2: Estimated Worldwide Mine Production of Vanadium (metric tons) | | | | | |
|---|---------------|---------------|---------------|---------------|---------------|
| Country | 2015 | 2016 | 2017 | 2018 | 2019 |
| China | 42,000 | 45,000 | 40,000 | 40,000 | 40,000 |
| Russia | 16,000 | 16,000 | 18,000 | 18,000 | 18,000 |
| South Africa | 12,000 | 10,000 | 7,960 | 7,700 | 8,000 |
| Brazil | 6,000 | 8,000 | 5,210 | 5,500 | 7,000 |
| United States | 0 | 0 | 0 | 0 | 460 |
| Total | 76,000 | 79,000 | 71,200 | 71,200 | 73,000 |
| Source: United States Geological Survey Mineral Commodity Summaries – Vanadium, https://www.usgs.gov/centers/nmic/vanadium-statistics-and-information , and Energy Fuels 2019 SEC 10-K filing | | | | | |

Energy Fuels sold approximately 50,000 of the 460,000 kilograms of contained vanadium it produced in 2019, with the remainder kept in inventory.²⁷ The company reports that its U.S. mines contain 6.6 million kilograms of measured vanadium content, with another 3.6 million

²⁵ United States Geological Survey Mineral Commodity Summaries – Vanadium, <https://www.usgs.gov/centers/nmic/vanadium-statistics-and-information>

²⁶ Energy Fuels, Inc. 2019 SEC Form 10-K, <https://www.energyfuels.com/financials>

²⁷ Energy Fuels, Inc. 2019 Annual Presentation, <https://www.energyfuels.com/presentation>

kilograms indicated or inferred.²⁸ Energy Fuels also operates the only U.S. facility that can process both vanadium ore and conventional uranium, the White Mesa Mill.

Two Canada-based companies are in the process of exploring the development of mines located in the United States. In May 2020, First Vanadium Corporation announced the results of its Preliminary Economic Assessment (PEA) for an open pit mine near Carlin, Nevada, and forecast 16 years of vanadium production capabilities totaling 180 million pounds of vanadium pentoxide, equivalent to 46 million kilograms of vanadium content.²⁹ The second company, Silver Elephant Mining, owns Nevada Vanadium LLC, which is in the process of developing the Gibellini vanadium project near Eureka, Nevada. The Gibellini project is in the permitting process, with the Bureau of Land Management expected to reach a decision by August 2021.³⁰ The company plans to begin production in late 2023, producing 130 million pounds of vanadium pentoxide (33 million kilograms of vanadium content) over 14 years.³¹ Other domestic vanadium resources exist, including Western Uranium & Vanadium's Sunday Mine Complex in Colorado and Anfield Resources' Velvet-Wood Mine in Utah, both of which have previously produced vanadium and have the potential to provide primary sources of vanadium, should market conditions support such production. In 2017, the United States Geological Survey (USGS) listed a total of 18 vanadium deposits in the United States, though data was not available on the extent of the deposits for most.³² The identification of most of these deposits is drawn from assessments carried out in 1968 and 1975 by the American Institute of Mining, Metallurgical, and Petroleum Engineers and the U.S. Geological Survey.³³

²⁸ Ibid.

²⁹ "First Vanadium Announces Positive Preliminary Economic Assessment for the Carlin Vanadium Project in Nevada", <https://www.firstvanadium.com/index.php/news/2020/548-firstvanadiumannouncespositivepreliminaryeconomicassessment20200511>

³⁰ Bureau of Land Management Accepting Comments for Gibellini Mine, August 17, 2020. Available at <https://www.blm.gov/press-release/bureau-land-management-accepting-comments-gibellini-mine>

³¹ Silver Elephant Mining Corporate Presentation: Gibellini Vanadium, <https://www.silverelephantmining.com/projects/gibellini-vanadium/>

³² Vanadium: Chapter U of Critical Mineral Resources of the United States—Economic and Environmental Geology Prospects for Future Supply (2017). <https://pubs.usgs.gov/pp/1802/u/pp1802u.pdf>

³³ Fischer, R.P., 1968, The uranium and vanadium deposits of the Colorado Plateau region, in Ridge, J.D., ed., Ore deposits of the United States, 1933–1967: New York, N.Y., American Institute of Mining, Metallurgical, and Petroleum Engineers; Fischer, R.P., 1975, Geology and resources of base-metal vanadate deposits: U.S.

Worldwide, most vanadium is produced via co-production with steelmaking, with vanadium-bearing iron ore used in steel furnaces that produce a vanadium slag that is further converted into vanadium pentoxide and ferrovanadium. Co-production accounted for 71% of global vanadium production in 2019.³⁴ The concentrations of vanadium-bearing iron ore in China, Russia, and South Africa have made co-production more economically feasible in these countries than in others.

The main method of vanadium production in the United States is secondary production, using fossil fuel spent catalysts, residues, and ashes as feedstock. Fossil fuels can produce vanadium-bearing waste both through the use of vanadium catalysts used in the refining process and in the vanadium-rich residues generated from the burning of fuels high in vanadium content. After recovery, the spent catalysts and residues can be processed into vanadium pentoxide and ferrovanadium (see Figure 3). Secondary production of vanadium accounted for an estimated 11% of worldwide vanadium production in 2019, with the United States accounting for roughly one-third of the worldwide total (4% of total global production).³⁵

Geological Survey Professional Paper 926–A, <http://pubs.er.usgs.gov/publication/pp926A> and Fischer, R.P., 1975, Vanadium resources in titaniferous magnetite deposits: U.S. Geological Survey Professional Paper 926–B, <http://pubs.er.usgs.gov/publication/pp926B>

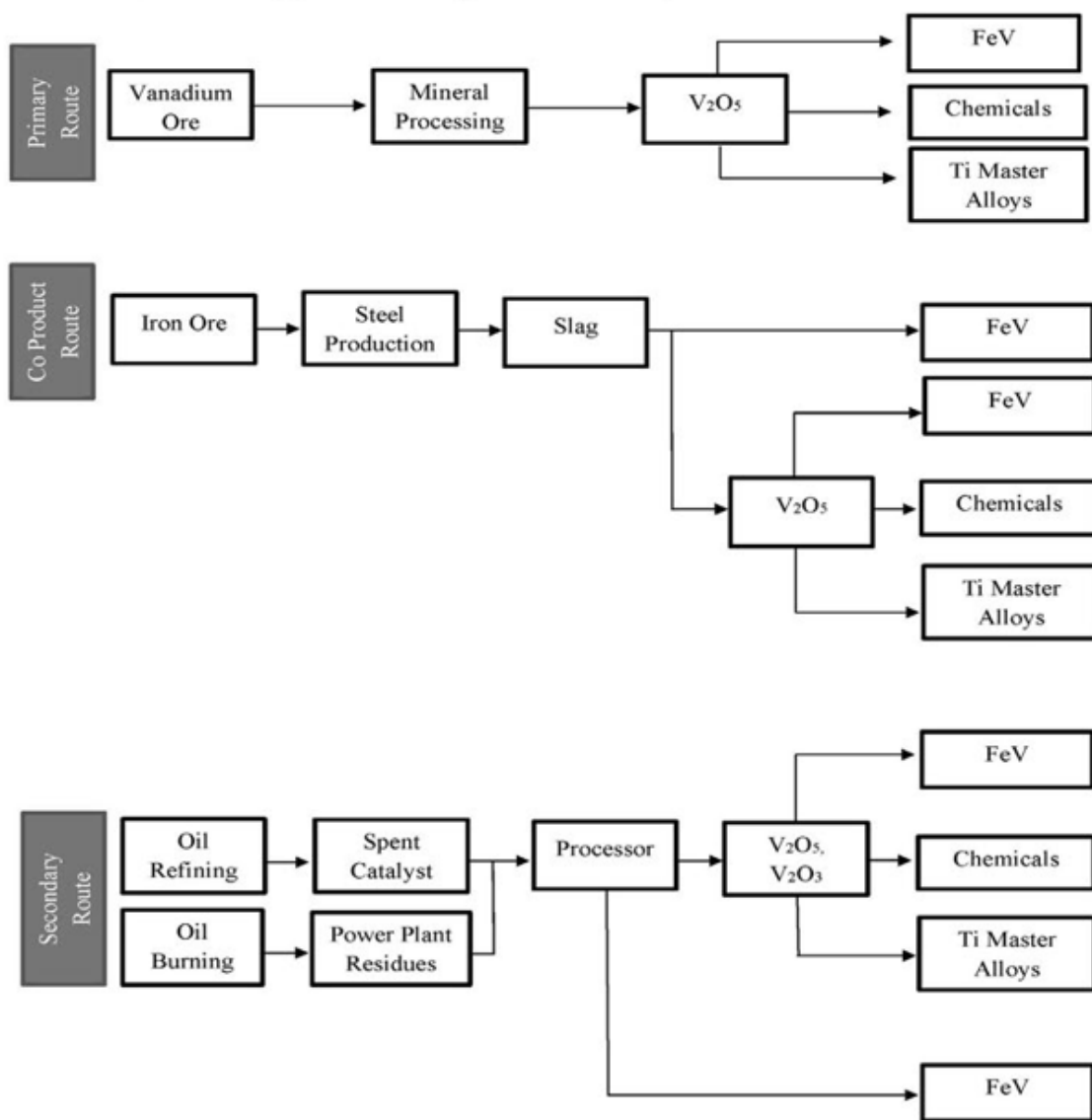
³⁴ Bushveld Minerals, About Vanadium, <https://www.bushveldminerals.com/about-vanadium/>.

³⁵ Ibid.

Figure 3: Vanadium Processing Routes

Vanadium Processing Routes

- Three Vanadium processing routes
 - Primary, Co Product, and Secondary



Source: Petition for Relief Under Section 232, available at <https://www.regulations.gov>, docket BIS-2020-0002, Document, BIS-2020-0002-0083

Both Applicants are secondary producers of vanadium, using vanadium-bearing waste feedstock to produce vanadium products: AMG Vanadium operates a facility in Cambridge, Ohio that produces ferrovanadium, and U.S. Vanadium operates a facility in Hot Springs,

Arkansas that produces vanadium pentoxide. In addition to the Applicants there is one other domestic secondary vanadium producer: Gladieux Metals Recycling in Freeport, Texas and one converter: Evergreen Metallurgical (doing business as Bear Metallurgical Company) in Butler, Pennsylvania.

AMG Vanadium's Ohio facility, which was originally built by the Vanadium Corporation of America, dates to 1952. Updates to the facility in 1970, following a merger with the Foote Mineral Corporation, led to the use of vanadium bearing slag as the facility's raw material input. A further overhaul after the acquisition of the facility by Advanced Metallurgical Group NV in 2007 resulted in AMG Vanadium's current use of spent catalyst as feedstock.³⁶

AMG Vanadium is the country's largest producer of ferrovanadium, with average annual production from 2016 to 2019 of [TEXT REDACTED].³⁷ As stated above, the company uses vanadium-bearing spent catalyst as feedstock; [TEXT REDACTED].³⁸

The completion of a new facility in Zanesville, Ohio (approximately 25 miles from its existing Cambridge facility) will allow AMG Vanadium to more than double its ferrovanadium production capacity to 5.5 million kilograms per year.³⁹ The new facility is expected to be completed in 2021, at a cost of just over \$200 million, and will support approximately 100 new jobs.⁴⁰ The company has indicated that its expansion makes sense despite low vanadium prices, based on the fees it receives from refiners to process spent catalyst, which they expect to exceed their operating costs in 2021.⁴¹ [TEXT REDACTED]⁴²

³⁶ AMG Vanadium: Our History, at https://amg-v.com/timeline_amg_v/

³⁷ U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey.

³⁸ Ibid.

³⁹ AMG Vanadium to Duplicate Ohio Recycling Facility. <https://www.spglobal.com/marketintelligence/en/news-insights/trending/2zqx3jqhyx72gfgkcwuzq2>

⁴⁰ AMG Vanadium Constructing a Second Ohio Plant, Investing More Than \$200 Million. <https://www.jobsohio.com/news/posts/amg-vanadium-constructing-a-second-ohio-plant-investing-more-than-200-million/>

⁴¹ AMG Annual General Meeting Minutes (May 1, 2019), as provided in public comments by Bushveld Minerals Limited, available at <https://www.regulations.gov/document?D=BIS-2020-0002-0013>

⁴² U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey.

In October 2019, U.S. Vanadium LLC (U.S. Vanadium) purchased the vanadium production facility located in Hot Springs, Arkansas, from EVRAZ Stratcor (Stratcor), which had owned the facility since 2006. Vanadium production in Hot Springs dates from mining and milling operations established in 1966 by Union Carbide Corporation, which sold the mill to Stratcor in 1986 and closed the mine in 1989.⁴³

U.S. Vanadium was the only company to produce vanadium pentoxide in the United States in 2020, following Energy Fuels' cessation of production and the ongoing idling of Gladieux Metals Recycling. [TEXT REDACTED]⁴⁴

Gladieux Metals Recycling (Gladieux) is the owner of an idle vanadium production facility in Freeport, Texas, which it purchased out of bankruptcy from Gulf Chemical and Metallurgical Corporation (Gulf) in 2017.⁴⁵ Gulf, which was majority-owned by the French company Eramet, had entered into bankruptcy and idled the vanadium processing facility as a result of low vanadium and molybdenum prices as well as the costs arising from environmental challenges. These costs included 11 felony pollution charges and a resulting \$2.75 million fine in 2010, a \$7.5 million fine in 2013, and over \$50 million in capital expenditures related to environmental matters.⁴⁶ While the facility has been idle since 2017, Gladieux has been overhauling operations and has invested more than [TEXT REDACTED] to increase the plant's efficiency and make it more environmentally sound.⁴⁷

Gladieux expects to restart operations [TEXT REDACTED].⁴⁸ [TEXT REDACTED]. Gladieux will use spent catalyst as its feedstock; [TEXT REDACTED].⁴⁹

⁴³ Vanadium Mining, Encyclopedia of Arkansas. <https://encyclopediaofarkansas.net/entries/vanadium-mining-5915/>

⁴⁴ U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey.

⁴⁵ Callahan, Erinn. "Recycling company buys Gulf Chemical." *The Facts*, May 16, 2017. https://thefacts.com/news/article_fe738e6b-8b64-54fb-afd0-c66cbe35f63e.html

⁴⁶ Gulf Chemical & Metallurgical Corporation Chapter 11 Bankruptcy Filing, as provided in public comments by Bushveld Minerals Limited, available at <https://www.regulations.gov/document?D=BIS-2020-0002-0013>

⁴⁷ Gladieux Metals Recycling. Comment in response to Notice of Request for Public Comments on Section 232 National Security Investigation of Imports of Vanadium, July 20, 2020. <https://www.regulations.gov/document?D=BIS-2020-0002-0033>.

⁴⁸ U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey.

⁴⁹ Ibid.

Bear Metallurgical (Bear) owns a facility in Butler, Pennsylvania, which [TEXT REDACTED], but converts vanadium pentoxide to ferrovanadium, primarily on a fee basis for customers.⁵⁰ Bear reported that [TEXT REDACTED]⁵¹ Bear produced [TEXT REDACTED].⁵²

Prior to declaring bankruptcy in 2016, Bear was a wholly-owned subsidiary of Gulf Chemical and Metallurgical (Gulf). The company reported entering into bankruptcy because low vanadium and molybdenum prices limited their toll conversion volumes, with their reliance on Gulf being a significant factor; as noted above Gulf itself also declared bankruptcy in 2016, and subsequently idled vanadium pentoxide production.⁵³ Bear was purchased in 2016 by Yilmaden Holding, a subsidiary of the Turkey-based Yildirim Group.⁵⁴

[TEXT REDACTED].

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⁵⁰ Often referred to as a tolling arrangement, with Bear as the “toller” and their customers, who provide material to be converted, as “tollees.”

⁵¹ U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey.

⁵² Ibid

⁵³ Gulf Chemical & Metallurgical Corporation Chapter 11 Bankruptcy Filing, as provided in public comments by Bushveld Minerals Limited, available at <https://www.regulations.gov/document?D=BIS-2020-0002-0013>

⁵⁴ Mughal, Sarah. “Report: Yildirim Unit Wins Tender for Bear Metallurgical Assets.” September 11, 2016. *S&P Global Market Intelligence*. <https://www.spglobal.com/marketintelligence/en/news-insights/trending/tetcr1ex6irl2ixbbkkqtw2>

⁵⁵ USGS Vanadium Mineral Commodity Summary, 2020. <https://pubs.usgs.gov/periodicals/mcs2020/mcs2020-vanadium.pdf>

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B. Vanadium Uses

The vast majority of vanadium is used in steelmaking. Estimates for both U.S. and worldwide usage put the steel industry at 90 to 93% of total vanadium usage.⁵⁶ The inclusion of small amounts of vanadium—typically well under 1% of the total volume—into steel adds “strength, toughness, and wear resistance,” as well as oxidation prevention.⁵⁷ The resulting high-strength, low-alloy (HSLA) steel products are common in the construction industry, particularly in earthquake-resistant rebar, as well as in buildings, bridges, and cranes. HSLA steel products are also used in the automotive sector, in shipbuilding, and in various defense-related uses such as armor plating.⁵⁸ Additionally, use of vanadium is common in tool steel, with chromium-vanadium steel commonly used in hand tools with vanadium concentrations of 0.15 to 0.2%.⁵⁹ Vanadium is also used at significantly higher concentrations in high speed steel used in cutting and drilling tools, as well as aerospace applications such as gas engine turbines, at concentrations that can exceed 5% vanadium.

Substitution for vanadium is possible in most steel products. Molybdenum produces similar mechanical properties in tool steels and is substituted on the basis of price and the existence of pre-established supply chains.⁶⁰ In HSLA steels, niobium is a standard substitute for

⁵⁶ Vanadium: Chapter U of Critical Mineral Resources of the United States—Economic and Environmental Geology Prospects for Future Supply (2017). <https://pubs.usgs.gov/pp/1802/u/pp1802u.pdf>

⁵⁷ Ibid.

⁵⁸ Ibid.

⁵⁹ Which is better for hand tools? Chromium-Molybdenum or Chromium-Vanadium Steel. <https://www.tekton.com/crmo-or-crv-steel>

⁶⁰ Ibid.

vanadium, though “significant technical adjustments to the steel production process” are required.⁶¹ Many Chinese steel mills, for instance, carried out this substitution in 2018 in response to a surge in vanadium prices.⁶² Nonetheless, vanadium is generally preferred in applications such as rebar, though Roskill—a major metal and chemical industry research and consultancy group—notes that “once mills are accustomed to niobium and have made the technical changes, they are unlikely to fully switch back.”⁶³

Compared to its use in steel alloys, the aggregate use of vanadium in titanium alloys accounts for a much smaller percentage—approximately 3 to 5% of total vanadium demand—but it is “irreplaceable in aerospace applications.”⁶⁴ Most titanium products contain vanadium; the vanadium is typically incorporated into the titanium melt process as a master alloy that is 65% vanadium and 35% aluminum, producing a variety of titanium mill products. The most common is Ti-6Al-4V, a product that is 4% vanadium by weight and between 12 and 14% by cost.⁶⁵ Other titanium alloys contain up to 15% vanadium by weight.

Most titanium products are used in the aerospace and military sectors, which account for approximately two-thirds of titanium mill product demand.⁶⁶ Titanium accounts for approximately 14% of the Boeing 787 airframe, for instance, and up to 39% of the weight of F-22 fighter jet.⁶⁷ Other national security titanium applications include ship components, military ground vehicles, and armor. Industrial use of titanium accounts for approximately 25% of

⁶¹ Vanadium: Chapter U of Critical Mineral Resources of the United States—Economic and Environmental Geology Prospects for Future Supply (2017). <https://pubs.usgs.gov/pp/1802/u/pp1802u.pdf>

⁶² Press Release: Roskill: Niobium industry looking for a future beyond steel. <https://www.globenewswire.com/news-release/2020/02/10/1982500/0/en/Roskill-Niobium-industry-looking-for-a-future-beyond-steel.html>

⁶³ Vanadium Outlook to 2029, 18th Edition, Publicly available summary, <https://roskill.com/market-report/vanadium/>

⁶⁴ Vanadium: Chapter U of Critical Mineral Resources of the United States—Economic and Environmental Geology Prospects for Future Supply (2017). <https://pubs.usgs.gov/pp/1802/u/pp1802u.pdf>

⁶⁵ Titanium Metals Corporation Public Comment on Section 232 National Security Investigation of Imports of Vanadium. Available at <https://www.regulations.gov/document?D=BIS-2020-0002-0019>

⁶⁶ Olin, Chris. Titanium Market Update: Highlighting Global Trends in 2017. Longbow Research.

⁶⁷ Boeing 787: From the Ground Up. https://www.boeing.com/commercial/aeromagazine/articles/qtr_4_06/article_04_2.html and U.S. Department of Commerce. Bureau of Industry and Security. *The Effect of Imports of Titanium Sponge on the National Security*.

demand; vanadium is used in the chemical industry, power plants, and desalination plants, but these sectors are more likely to use unalloyed “commercially pure” titanium.

The primary remaining vanadium uses, accounting for 2 to 4% of total vanadium demand, are categorized as chemical or non-metallurgical use. One key non-metallurgical use is in catalysts, with vanadium-based products being the most common catalysts used for selective catalytic reduction to reduce the production of nitrogen oxides in industrial power plants.⁶⁸ Vanadium is used as a catalyst in the production of sulfuric acid, itself an important industrial material used in the production of fertilizer, pulp and paper, titanium dioxide, cellulosic fibers and plastics, explosives, electronic chips, batteries, and pharmaceuticals.⁶⁹ Consumption of sulfuric acid is “regarded as one of the best indexes of a nation’s industrial development.”⁷⁰ A significant national security use of vanadium within the chemical industry is in longwave-infrared (LWIR) imaging, used for night vision and targeting systems. Vanadium oxide is the most frequently used material in the bolometers supporting LWIR imaging.⁷¹

An additional chemical use of vanadium is in large scale batteries. This accounts for a very small percentage of current usage—estimated well under 1% of total demand—but is an area in which some researchers have seen potential for significant expansion. Vanadium redox flow batteries (VRBs) were first patented in 1986, and VRB technology was advanced by Pacific Northwest National Laboratory in 2011, significantly shrinking the size of the batteries and increasing temperature tolerance.⁷² These batteries have attributes that make them valuable for use in energy grids such as longer life cycles, lack electrolyte cross-contamination, and the

⁶⁸ Types of Catalysts for SCR Operations, <https://sviindustrial.com/2020/04/08/types-of-catalysts-for-scr-operations/>

⁶⁹ PubChem Sulfuric acid compound summary, NIH National Library of Medicine, National Center for Biotechnology Information. <https://pubchem.ncbi.nlm.nih.gov/compound/Sulfuric-acid#section=Uses>

⁷⁰ National Mineral Information Center, Sulfur Statistics and information. <https://www.usgs.gov/centers/nmic/sulfur-statistics-and-information>

⁷¹ Andrew Voshell, Nibir Dhar, Mukti M. Rana, "Materials for microbolometers: vanadium oxide or silicon derivatives," Proc. SPIE 10209, Image Sensing Technologies: Materials, Devices, Systems, and Applications IV, 102090M (28 April 2017); doi: 10.1117/12.2263999

⁷² Yang, Z Gary. It’s Big and Long-Lived, and It Won’t Catch Fire: The Vanadium Redox-Flow Battery. IEEE Spectrum, October 26, 2017. <https://spectrum.ieee.org/green-tech/fuel-cells/its-big-and-longlived-and-it-wont-catch-fire-the-vanadium-redoxflow-battery>

ability to remain idle without losing capacity.⁷³ The vanadium accounts for approximately 30% of the cost of a vanadium redox flow battery, requiring between 3 and 6 kilograms of vanadium per kilowatt-hour of energy storage.⁷⁴ Estimates of the potential market growth of the vanadium redox flow battery vary wildly, from minimal amounts to estimates exceeding 40% compound annual growth.⁷⁵ To date, use of vanadium redox flow batteries has not shown sharp growth, in part due to cost. As the Department of Energy noted as part of its 2020 Energy Storage Grand Challenge Draft Roadmap, “future capital cost reductions will require replacing vanadium with lower cost raw materials to approach the \$100/kWh targets required for wider-scale deployment of energy storage.”⁷⁶

VI. Global Vanadium Industry Conditions

A. Overview

Primary and co-production of vanadium is largely undertaken in four countries: China, Russia, South Africa, and Brazil (see Figure 5). In addition to these countries, the United States Geological Survey (USGS) lists known reserves in the United States and Australia. Worldwide resources significantly exceed known reserves, which are considered “a working inventory of mining companies’ supplies of an economically extractable mineral commodity;” global reserves are estimated at 22 million metric tons, with world vanadium resources estimated to exceed 63 million metric tons.⁷⁷

⁷³ Vanadium Redox Flow Batteries: Improving the performance and reducing the cost of vanadium redox flow batteries for large-scale energy storage. October 2013. U.S. Department of Energy Electricity Delivery & Energy Reliability, Energy Storage Program. Available at <https://www.energy.gov/sites/prod/files/VRB.pdf>

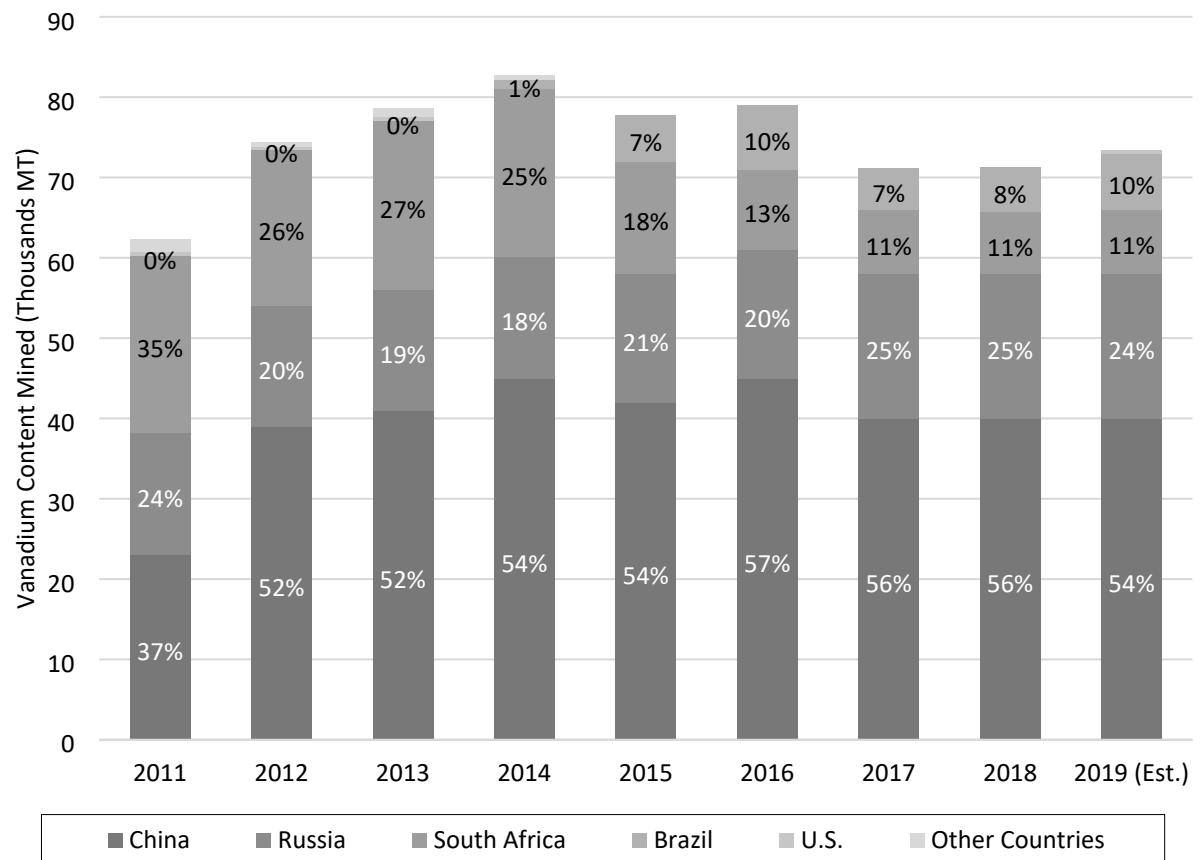
⁷⁴ Energy Storage & Vanadium Redox Flow Batteries 101, November 13, 2018. <http://www.bushveldminerals.com/wp-content/uploads/2018/11/Energy-Storage-Vanadium-Redox-Flow-Batteries-101.pdf>

⁷⁵ Ibid.

⁷⁶ Department of Energy, “Energy Storage Grand Challenge Draft Roadmap”, available at <https://www.energy.gov/energy-storage-grand-challenge/energy-storage-grand-challenge>

⁷⁷ United States Geological Survey Mineral Commodity Summaries – Vanadium, <https://www.usgs.gov/centers/nmic/vanadium-statistics-and-information>

Figure 5: World Vanadium Mine Production, 2011 - 2019



Source: U.S. Geological Survey

Countries other than the United States that are in the process of developing significant reserves include Canada and Kazakhstan. Australia already maintains notable vanadium reserves,

which it is seeking to expand, but does not have any recorded mine production. The Government of Australia reports nine vanadium production projects underway, with five of these at advanced stages of exploration, and some vanadium production possible in 2021.⁷⁸ One mine—the Windimurra mine—completed a feasibility study in April 2020 and expects to produce 4,250 tons of vanadium content annually.⁷⁹ The Windimurra mine has successfully produced vanadium in the past, operating from 1999 to 2003 with an annual production capacity of 3,000 tons contained vanadium.⁸⁰ Four other Australian projects are in the process of permitting, design, or pilot studies with a total potential annual production of 22,000 tons of contained vanadium.⁸¹

Several mining projects for vanadium-bearing iron ore in Canada are in exploratory phases. Two are in the Lac Doré area of Québec, with partial funding provided by the government of Québec. One of the two, operated by BlackRock Metals, plans to begin operations in 2021, with cast iron and ferrovanadium as the main products.⁸² This project is expected to yield 5,200 tons of ferrovanadium annually with 80% vanadium content, to be processed at a nearby facility.⁸³ The second company, VanadiumCorp Resources, is in the exploration phase, with drill testing programs completed in 2019 and a mineral resource estimate completed in October 2020.⁸⁴ The estimate showed 8 million metric tons of measured magnetite concentrate at 1.2% vanadium pentoxide content, equal to 56,000 tons of contained vanadium, with an additional 324,000 tons indicated and 155,000 tons inferred.⁸⁵ A third Canadian

⁷⁸ Submission from the Australian Government to the United States Department of Commerce, Section 232 National Security Investigation into Imports of Vanadium, submitted to <https://www.regulations.gov>, docket BIS-2020-0002 July 20, 2020.

⁷⁹ Ibid.

⁸⁰ United States Geological Survey, Vanadium Minerals Yearbook reports. Available at <https://www.usgs.gov/centers/nmic/vanadium-statistics-and-information>

⁸¹ Submission from the Australian Government to the United States Department of Commerce, Section 232 National Security Investigation into Imports of Vanadium, submitted to <https://www.regulations.gov>, docket BIS-2020-0002 July 20, 2020.

⁸² “Métaux BlackRock a un client pour son titane”, Radio-Canada, May 8, 2019, <https://ici.radio-canada.ca/nouvelle/1168744/ferrovanadium-usine-saguenay-client-mine-chibougamau>

⁸³ “BlackRock Project: Iron Ore Exploitation at lac Doré”, <https://iaac-aeic.gc.ca/050/documents/p62105/90319E.pdf>

⁸⁴ VanadiumCorp Lac Doré Vanadium Project, <http://www.vanadiumcorp.com/projects/lac-dore-vanadium-project/>

⁸⁵ VanadiumCorp Reports Lac Dore Mineral Resource Estimate (MRE). October 29, 2020. <https://www.vanadiumcorp.com/releases/vanadiumcorp-reports-the-lac-dore-mineral-resource-estimate-mre-2/>

company, Vanadium One Iron Corporation, released the results of its PEA in February 2020 for its Mont Sorcier property in Québec, anticipating the ability to produce five million tons of ore per year with a 0.6% vanadium pentoxide content.⁸⁶

| Figure 6: Estimated New Mine Production Potential of Select Vanadium Projects in Canada and Australia (in metric tons contained vanadium) | | | | |
|---|--|--|--------------------|-----------------------------|
| Country | Project | Status | Estimated Reserves | Estimated Annual Production |
| Australia | Atlantic Vanadium: Windimurra Mine | In Development | 131,936 | 4,256 |
| Australia | Multicom: Saint Elmo Mine | Finalizing Environmental Approvals | 112,000 | 5,600 |
| Australia | Australian Vanadium Ltd: Australian Vanadium Project | Feasibility Study | 97,152 | 5,715 |
| Australia | TNG Limited: Mount Peake Mine | Engineering Design | 124,320 | 3,360 |
| Australia | Technology Metals Australia: Gabanintha Mine | Feasibility Study Completed 2019 | 114,688 | 7,168 |
| Australia | Total | --- | 580,096 | 26,099 |
| Canada | BlackRock Metals: Chibougamou Mine | Authorized | 176,439 | 4,152 |
| Canada | VanadiumCorp Resources: Lac Doré Project | Mineral Resource Estimate Complete | 379,273 | 10,306 |
| Canada | VanadiumOne: Mont Sorcier Project | Preliminary Economic Analysis Complete | 117,600 | 16,800 |
| Canada | Total | --- | 673,312 | 31,258 |
| Sources: Submission from the Australian Government to the United States Department of Commerce, Section 232 National Security Investigation into Imports of Vanadium, submitted to https://www.regulations.gov , docket BIS-2020-0002 July 20, 2020. BlackRock Mining Project Summary. Available at https://comexqc.ca/en/fiches-de-projet/projet-dexploitation-dun-gisement-fer-vanadium-metaux-blackrock-inc/ VanadiumCorp Reports Lac Doré Mineral Resource Estimate. October 29, 2020. Available at https://www.vanadiumcorp.com/releases/vanadiumcorp-reports-the-lac-dore-mineral-resource-estimate-mre-2/ VanadiumOne Iron Corp. Preliminary Economic Analysis Results, February 2020. Available at https://www.vanadiumone.com/pea-results/ | | | | |

In Kazakhstan, the Ferro-Alloy Resources Group, based in Guernsey and listed on the London and Astana International Stock Exchanges, owns Firma Balusa, LLP, which holds the

⁸⁶ Vanadium One Iron Corporation PEA Results, February 2020, <https://www.vanadiumone.com/pea-results/>

rights to the Balasausqandiq vanadium deposit in the southern part of the country. The site currently has minimal vanadium production, but has rapid expansion plans, forecasting in 2019 reaching production levels of 4,000 tons contained vanadium in 2020 and 13,000 tons in 2023.⁸⁷ The projected 2023 production would make Kazakhstan the world's third leading producer of mined vanadium based on current totals. The company's production levels appear significantly behind its initial plans, attributed primarily to the COVID-19 pandemic; through August of 2020 the company indicated it had produced 168 tons of vanadium pentoxide (94 tons contained vanadium) from secondary concentrate, and indicated the development of the Balasausqandiq deposit was ongoing.⁸⁸ The company says it "plans to become the world's lowest cost primary producer."⁸⁹

Beyond the estimated 73,000 tons of mine-produced vanadium reported worldwide in 2019, secondary production added as much as 30,000 tons to worldwide totals, with most of the additional production in the U.S., Germany, Austria, Japan, and Taiwan.⁹⁰ Significant producers outside of the U.S. include Treibacher in Austria, AMG Technologies in Germany, Shinko Chemical, Taiyo Koko, and Metal Technology in Japan, and Hong Jing Environment, Plum Movax, and Full Yield Industry of Taiwan. Interest in secondary production has risen in recent years as tightened environmental controls on fuels has increased interest in processing spent catalyst and fossil fuel residues. In addition to their U.S. expansion, AMG is exploring the construction of facilities in Saudi Arabia and China to process catalysts from those regions.⁹¹

⁸⁷ Ferro-Alloy Resources Ltd Corporate Presentation, March 2019. <http://ferro-alloy.com/en/news/FAR%20-%20Corporate%20Presentation%20-%20%20update%20March%202019.pdf>

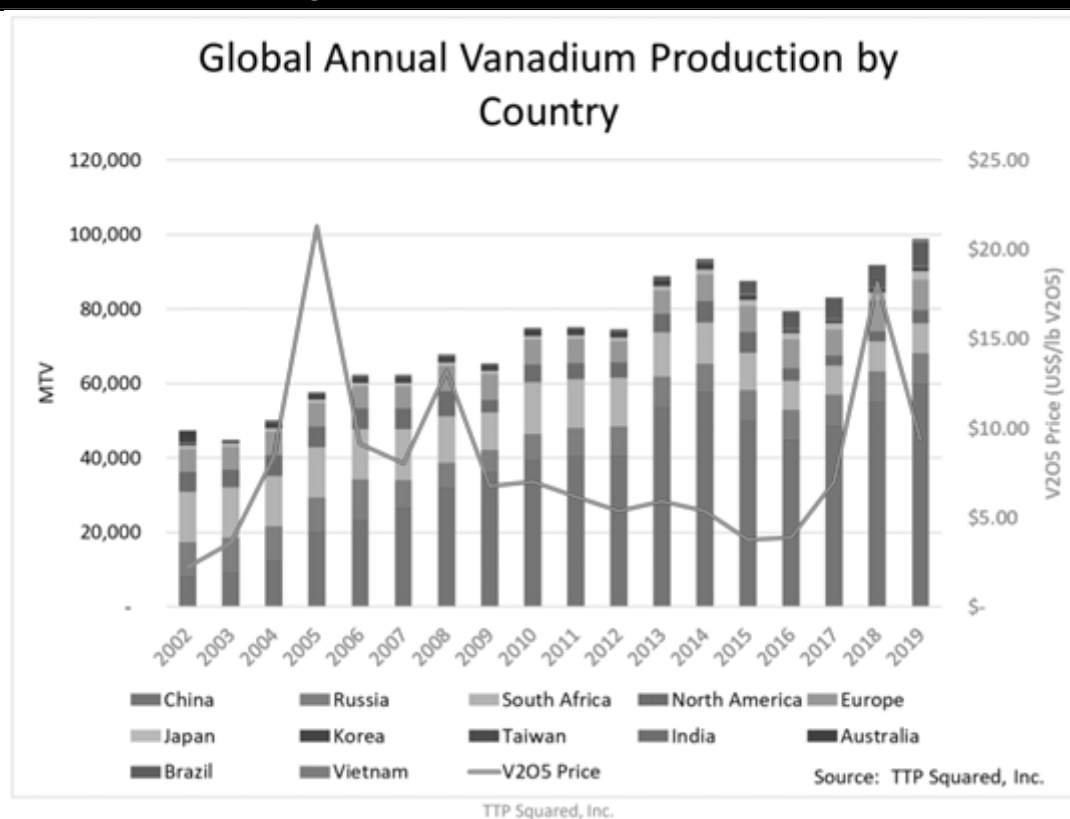
⁸⁸ Ferro-Alloy Resources Unaudited interim financial results for the six months to 30 June 2020. <http://www.ferro-alloy.com/en/investors/financials/>

⁸⁹ Ferro-Alloy Resources Corporate Profile. <http://www.ferro-alloy.com/en/company/corporate-profile/>

⁹⁰ Based on USGS estimates and Perles, Terry. Vanadium Market Fundamentals: China's 2019 4th International Vanadium Forum Chengdu, Sichuan, China. April 13, 2019. Submitted as public comment by Treibacher Industrie, July 20, 2020. Available at <https://www.regulations.gov/document?D=BIS-2020-0002-0026>

⁹¹ AMG 2019 Annual Report. Available at <https://ig9we1q348z124x3t10meupc-wpengine.netdna-ssl.com/wp-content/uploads/AMG-Annual-Report-Web-FINAL.pdf> and Shell & AMG Recycling B.V. Sign Agreement with Shandong Yulong Petrochemical Co., Ltd to Assess Building a Spent Residue Upgrading Catalyst Recycling Facility. Available at <https://www.globenewswire.com/news-release/2020/10/26/2114333/0/en/Shell-AMG-Recycling-B-V-Sign-Agreement-with-Shandong-Yulong-Petrochemical-Co-Ltd-to-Assess-Building-a-Spent-Residue-Upgrading-Catalyst-Recycling-Facility.html>

Figure 7: Vanadium Pentoxide Production



Source: Vanadium Market Analysis, Terry Perles, TTP Squared, April 3, 2020.

<http://www.ferro-alloy.com/en/vanadium/TTP%20Squared%20market%20summary%203%20April%202020.pdf>

While China accounts for an estimated 50 to 60% of global vanadium production, exports of vanadium from China constitute only approximately 15% of worldwide vanadium exports, because most Chinese production is consumed domestically in the steel industry. Primary producers South Africa and Brazil, as well as European Union countries, which represent a much larger share of global vanadium exports than production. The European Union alone accounts for over one-quarter of global exports of contained vanadium (see Figure 8).

Figure 8: Estimated 2019 Share of Production and Exports of Vanadium Content in Vanadium Pentoxide and Ferrovanadium

| Country | Estimated 2019 Share of World Production | Estimated 2019 Share of World Exports |
|---------------------------|--|---------------------------------------|
| China | 55% | 15% |
| Russia | 18% | 15% |
| European Union Countries* | 9% | 27% |
| South Africa | 8% | 13% |
| Brazil | 7% | 13% |
| United States | 4% | 4% |
| Japan | 2% | 1% |
| India | 1% | 1% |

| | | |
|--|-----|----|
| South Korea | <1% | 7% |
| Taiwan | <1% | 2% |
| Thailand | <1% | 1% |
| Canada | <1% | 2% |
| Sources: U.S. Geological Survey, TTP Squared, Bureau of Industry and Security, IHS Markit Global Trade Atlas | | |
| * Includes exports within the European Union | | |

Vanadium production generally results first in vanadium pentoxide, which may be exported or further processed into ferrovanadium for use in steel. A large portion of the difference between world production and export share for E.U. countries results from their import of vanadium oxides—principally from Russia—for conversion into ferrovanadium, which was then exported (see Figure 9). In fact, nearly all Russian exports of vanadium oxide went to the Czech Republic, home to EVRAZ Nikom, one of the E.U.’s main producers of ferrovanadium.

| Figure 9: Top World Trade Pairings 2016-2019: Vanadium Oxides (HTS 2825.30) (in tons vanadium oxide) | | | | | | | |
|--|-----------------|-------------|-------------|-------------|-------------|-----------------------------------|-------------------------------|
| Exporter | Importer | 2016 | 2017 | 2018 | 2019 | Share of Country's Exports | Share of World Exports |
| Russia | Czech Republic | 6,656 | 8,656 | 8,676 | 9,683 | 99% | 23% |
| South Africa | Netherlands | 3,415 | 3,225 | 3,871 | 3,711 | 56% | 10% |
| China | South Korea | 3,140 | 4,620 | 3,186 | 2,750 | 47% | 9% |
| Brazil | Netherlands | 1,740 | 4,343 | 4,039 | 3,380 | 37% | 9% |
| Brazil | South Korea | 3,640 | 1,460 | 660 | 2,320 | 22% | 5% |
| South Korea | Japan | 1,181 | 2,357 | 1,840 | 2,051 | 73% | 5% |
| South Africa | United States | 1,676 | 1,744 | 1,603 | 1,521 | 26% | 4% |
| Brazil | United States | 660 | 1,377 | 2,442 | 1,993 | 18% | 4% |
| China | Netherlands | 2,376 | 1,860 | 1,199 | 615 | 21% | 4% |
| Netherlands | Austria | 2 | 46 | 3,100 | 1,773 | 75% | 3% |
| Brazil | Canada | 980 | 940 | 1,320 | 1,340 | 13% | 3% |
| China | Japan | 926 | 720 | 917 | 722 | 11% | 2% |
| China | United States | 930 | 565 | 639 | 69 | 8% | 1% |
| Brazil | Japan | 680 | 440 | 440 | 440 | 6% | 1% |
| China | Canada | 120 | 420 | 599 | 510 | 6% | 1% |
| South Africa | Japan | 267 | 244 | 391 | 560 | 6% | 1% |
| Taiwan | United States | 533 | 510 | 57 | 126 | 38% | 1% |
| Thailand | India | 60 | 320 | 520 | 240 | 55% | 1% |
| Brazil | India | 260 | 660 | 200 | 0 | 3% | 1% |
| South Africa | India | 0 | 0 | 486 | 480 | 4% | 1% |
| All Countries | All Countries | 33,293 | 37,220 | 39,074 | 38,719 | --- | --- |
| Source: IHS Markit Global Trade Atlas | | | | | | | |

Czech ferrovanadium, in turn, was exported principally to the United States, Japan, Netherlands, and Germany (see Figure 10). Other major exporters of ferrovanadium include the

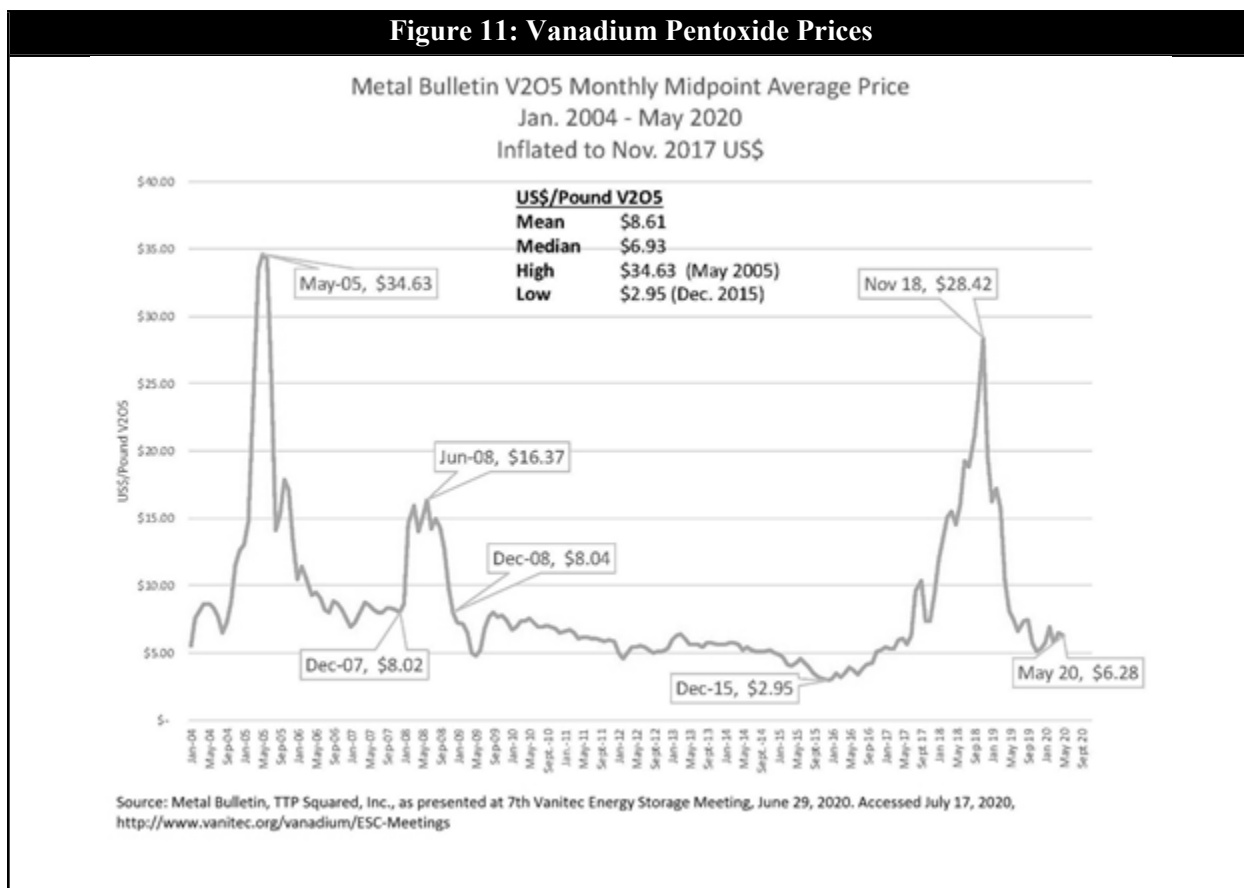
Netherlands (the principal importer of South African vanadium oxide), South Korea (the principal importer of Chinese vanadium oxides), and China which, despite exporting a relatively small percentage of their production still accounts for a major portion of global exports due to the sheer size of their production.

| Figure 10: Top World Trade Pairings 2016-2019: Ferrovanadium (HTS 7202.92) (in tons ferrovanadium) | | | | | | | |
|---|-----------------|-------------|-------------|-------------|-------------|---|---------------------------------------|
| Exporter | Importer | 2016 | 2017 | 2018 | 2019 | Share of Country's Exports | Share of World Exports |
| Netherlands | Germany | 1,902 | 1,832 | 3,758 | 1,913 | 28% | 7% |
| South Africa | Netherlands | 2,112 | 1,662 | 1,563 | 1,579 | 59% | 5% |
| China | Netherlands | 2,380 | 1,540 | 1,549 | 930 | 28% | 5% |
| South Korea | Netherlands | 1,364 | 1,714 | 1,543 | 1,333 | 53% | 4% |
| China | Japan | 1,467 | 1,323 | 1,635 | 1,370 | 25% | 4% |
| China | South Korea | 975 | 995 | 1,667 | 1,661 | 23% | 4% |
| Czech Republic | United States | 1,016 | 940 | 1,045 | 1,691 | 18% | 3% |
| Netherlands | United States | 1,398 | 186 | 2,091 | 893 | 13% | 3% |
| Czech Republic | Japan | 1,025 | 740 | 1,020 | 806 | 14% | 3% |
| Netherlands | Italy | 718 | 895 | 1,039 | 523 | 9% | 2% |
| China | Taiwan | 1,109 | 595 | 787 | 644 | 14% | 2% |
| Canada | United States | 142 | 767 | 869 | 1,266 | 91% | 2% |
| United States | Canada | 474 | 295 | 1,403 | 843 | 59% | 2% |
| Czech Republic | Netherlands | 870 | 457 | 270 | 1,184 | 11% | 2% |
| Czech Republic | Germany | 1,162 | 1,009 | 361 | 247 | 11% | 2% |
| Netherlands | Spain | 784 | 654 | 484 | 175 | 6% | 2% |
| South Africa | Japan | 312 | 404 | 605 | 640 | 17% | 1% |
| South Korea | Japan | 596 | 258 | 459 | 601 | 17% | 1% |
| Russia | Netherlands | 404 | 700 | 360 | 420 | 32% | 1% |
| United States | Mexico | 304 | 266 | 642 | 315 | 30% | 1% |
| All Countries | All Countries | 33,477 | 30,849 | 39,300 | 32,367 | --- | --- |
| Source: IHS Markit Global Trade Atlas | | | | | | | |

In recent years, the global vanadium market has been subject to severe price fluctuations. Three times since 2004 the benchmark vanadium pentoxide price has more than doubled in under a year, after which a precipitous drop to more typical price levels occurs (see Figure 11). These rapid price changes have led to a history of investment and expansion during price spikes and plant idlings and bankruptcies in market economies during and following price drops. Starting new primary production has been especially challenging, as new mining ventures can take many years to progress through exploration and permitting to production. The Windimurra mine in Australia, for instance, is in the midst of its fourth re-opening attempt since 1999, having operated from 2000 to 2003, invested in reopening from 2005 to 2009 that ultimately failed to

materialize, reopening with new ownership from 2012 to 2014, and currently under development by a new owner.⁹²

Figure 11: Vanadium Pentoxide Prices



⁹² McKinnon, Stuart. Vanadium Price Boom Offers Hope of Windimurra Revival. *The West Australian*, April 2, 2018. Available at <https://thewest.com.au/business/mining/vanadium-price-boom-offers-hope-of-windimurra-revival-ng-b88792684z>

Compared to primary production facilities, secondary production facilities can have less extended lead times, but still take years to complete. The establishment of AMG Vanadium’s new facility in Ohio was announced in October 2018, broke ground in August 2019, and is expected to be completed in 2021.⁹³ The Gladieux facility in Freeport, Texas was purchased in 2017 and is not yet operational.

B. Prior Trade Investigations

The U.S. government has previously taken action against artificially low-priced vanadium product imports. Several antidumping investigations conducted by the Department of Commerce and the USITC affirm that sources of imported ferrovanadium from nearly all countries that mine vanadium ore have engaged in dumping that injures U.S. producers. Among the significant miners of vanadium ore, only Brazil has not been subject to an antidumping finding. AMG Vanadium (or its predecessor) has been a petitioner for all ferrovanadium antidumping cases, joined by Bear, Gulf, and Stratcor (or its predecessor) for the petitions on China, South Africa, and Korea. Figure 12 lists USITC investigations into vanadium imports since 1995:

| Figure 12: U.S. International Trade Commission Vanadium Cases Since 1995 | | |
|--|--------------------|-------------|
| Investigation | Date | Finding |
| Ferrovanadium and Nitrided Vanadium from Russia | July 30, 1995 | Affirmative |
| Ferrovanadium and Nitrided Vanadium from Russia (First Review) | May 15, 2001 | Affirmative |
| Ferrovanadium from China and South Africa | January 28, 2003 | Affirmative |
| Ferrovanadium and Nitrided Vanadium from Russia (Second Review) | September 28, 2006 | Affirmative |
| Ferrovanadium from China and South Africa (First Review) | November 24, 2008 | Affirmative |
| Ferrovanadium from China and South Africa (Second Review) | January 28, 2015 | Affirmative |
| Ferrovanadium and Nitrided Vanadium from Russia (Third Review) | August 22, 2012 | Negative |

⁹³ AMG Vanadium Muskingum County Facility Website. <https://amg-v.com/muskingumfacility/>

| | | |
|---|----------------|-------------|
| Ferrovandium from Korea | March 17, 2017 | Affirmative |
| Ferrovandium from China and South Africa (Third Review) | August 7, 2020 | Affirmative |
| Source: United States International Trade Commission | | |

Russia

In July 1995, the Department of Commerce found that imports of ferrovandium and nitrated vanadium from Russia were sold in the United States at less than fair value, and the USITC found that the dumped imports were materially injuring the U.S. industry. In the course of the investigation, USITC determined that ferrovandium and nitrated vanadium, despite having somewhat disparate end uses, constituted a single like product based on the significant vanadium content and generally interchangeable use in steel alloys.⁹⁴

This affirmative finding was renewed following the Department of Commerce's and USITC's first five-year review of the antidumping duty order in May 2001, as well as the second five-year review in September 2006. At the third set of five-year reviews completed in August 2012, the USITC noted there had been no subject imports since 1996, and that in the case of nitrated vanadium there had been no U.S. production since 1992.⁹⁵ However, while there were no imports of ferrovandium from Russia during the time period, there were imports of Russian vanadium pentoxide, which were then converted to ferrovandium in the U.S., as well as imports of ferrovandium from Russian-owned EVRAZ Nikom in the Czech Republic, made from Russian-sourced vanadium pentoxide.⁹⁶

The USITC's third review found, contrary to the prior reviews, that imports of ferrovandium from Russia would not be likely to significantly increase if the antidumping order

⁹⁴ U.S. International Trade Commission. *Ferrovandium and Nitrated Vanadium from Russia*. Investigation No. 731-TA-702, Final. https://www.usitc.gov/publications/701_731/pub2904.pdf

⁹⁵ U.S. International Trade Commission. *Ferrovandium and Nitrated Vanadium from Russia*. Investigation No. 731-TA-702 (Third Review). https://www.usitc.gov/publications/701_731/pub4345.pdf

⁹⁶ Ibid.

was revoked. The decision noted that Russian capacity and production had declined from prior significant excesses, with less focus on exporting ferrovanadium.⁹⁷ The report also noted the increased tendency to supply the U.S. market with vanadium pentoxide, rather than the subject product ferrovanadium. On this basis, the antidumping order against Russian ferrovanadium was revoked in October 2011.

China and South Africa

In January 2003 the Department of Commerce determined that imports of ferrovanadium from China and South Africa were sold in the United States at less than fair value and the USITC found that the dumped imports were materially injuring the U.S. industry. In the first sunset reviews (completed November 2008), second sunset reviews (completed January 2015), and third sunset reviews (completed August 2020), the Department of Commerce and the USITC determined that revocation of the existing antidumping duty orders on ferrovanadium from China and South Africa would likely lead to continuation or recurrence of dumping and material injury to an industry in the United States within a reasonably foreseeable time.⁹⁸

Following the imposition of the antidumping order in 2002, imports of ferrovanadium from China fell from an average of 497,000 kilograms of contained vanadium per year from 1999 to 2001 to “zero or close to zero in every year since 2002.”⁹⁹ USITC cited China’s status as the world’s largest producer of ferrovanadium and its continued increases in capacity as reasons for an affirmative injury finding.

⁹⁷ Ibid.

⁹⁸ Ferrovanadium from the People's Republic of China and the Republic of South Africa: Continuation of Antidumping Duty Orders, 73 FR 77609, December 19, 2008; Ferrovanadium From the People's Republic of China and the Republic of South Africa: Continuation of Antidumping Duty Orders, 80 FR 8607, February 18, 2015; Ferrovanadium From the Republic of South Africa and the People's Republic of China: Continuation of Antidumping Duty Orders, 85 FR 51408, August 20, 2020.

⁹⁹ U.S. International Trade Commission. *Ferrovanadium and Nitrided Vanadium from China and South Africa*. Investigation Nos. 731-TA-986-987 (Third Review). https://www.usitc.gov/publications/701_731/pub5099.pdf

Imports of ferrovanadium from South Africa showed similar declines following the initial antidumping order. From an average of 758,000 kilograms of vanadium content per year from 1999 to 2001, by 2003 imports had fallen to account for no more than 0.1% of U.S. market share.¹⁰⁰ As was the case with Russian providers, since the imposition of antidumping duties South African vanadium has continued to enter the United States in other forms not subject to antidumping duties, such as vanadium pentoxide and nitrided vanadium.

Korea

In March 2017 the Department of Commerce determined that imports of ferrovanadium from Korea were sold in the United States at less than fair value and the USITC found that the dumped imports were materially injuring the U.S. industry. Unlike Russia, China, and South Africa, Korea is not a significant source of vanadium production. Rather, the USITC noted that Korean ferrovanadium was produced primarily from vanadium pentoxide originally sourced from China.¹⁰¹ The USITC found that ferrovanadium from Korea was sold in the United States in “increasing and significant volume ... at declining prices.”¹⁰²

C. U.S. Duties on Vanadium Imports

As of November 2020, all vanadium products in the scope of this investigation, with the exception of vanadium ore and concentrates (Harmonized Tariff Schedule of the United States (HTSUS) 2615.90.6090) and ash and residues containing vanadium (HTSUS 2620.40.0030 and 2620.99.1000) are subject to duties between 2 and 5.5% (see Figure 13).

| Figure 13: Duties on Vanadium Products | | |
|---|--------------------------|-------------|
| Heading/Subheading/Product | 10 Digit HTS Code | Duty |
| Vanadium Oxides | 2825.30.0010 | 5.5% |
| | 2825.30.0050 | 5.5% |
| Ferrovanadium | 7202.92.0000 | 4.2%* |
| Vanadium Carbides | 2849.90.5000 | 3.7% |

¹⁰⁰ Ibid.

¹⁰¹ U.S. International Trade Commission. *Ferrovanadium and Nitrided Vanadium from Korea*. Investigation Nos. 731-TA-1315. https://www.usitc.gov/publications/701_731/pub4683.pdf

¹⁰² Ibid.

| | | |
|---|--------------|------|
| Vanadates | 2841.90.1000 | 5.5% |
| Vanadium Ore and Concentrates | 2615.90.6090 | Free |
| Ash and Residues Containing Vanadium | 2620.40.0030 | Free |
| | 2620.99.1000 | Free |
| Vanadium Sulfate | 2833.29.3000 | 5.5% |
| Vanadium Hydrides, Nitrides, Azides, Silicides, and Borides | 2850.00.2000 | 5.5% |
| Vanadium, Unwrought and Wrought | 8112.92.7000 | 2% |
| | 8112.99.2000 | 2% |
| Source: United States International Trade Commission and U.S. Department of Commerce, Bureau of Industry and Security, as of December 7, 2020 | | |
| * Ferrovanadium products from China, South Africa, and Korea are subject to additional antidumping duties | | |

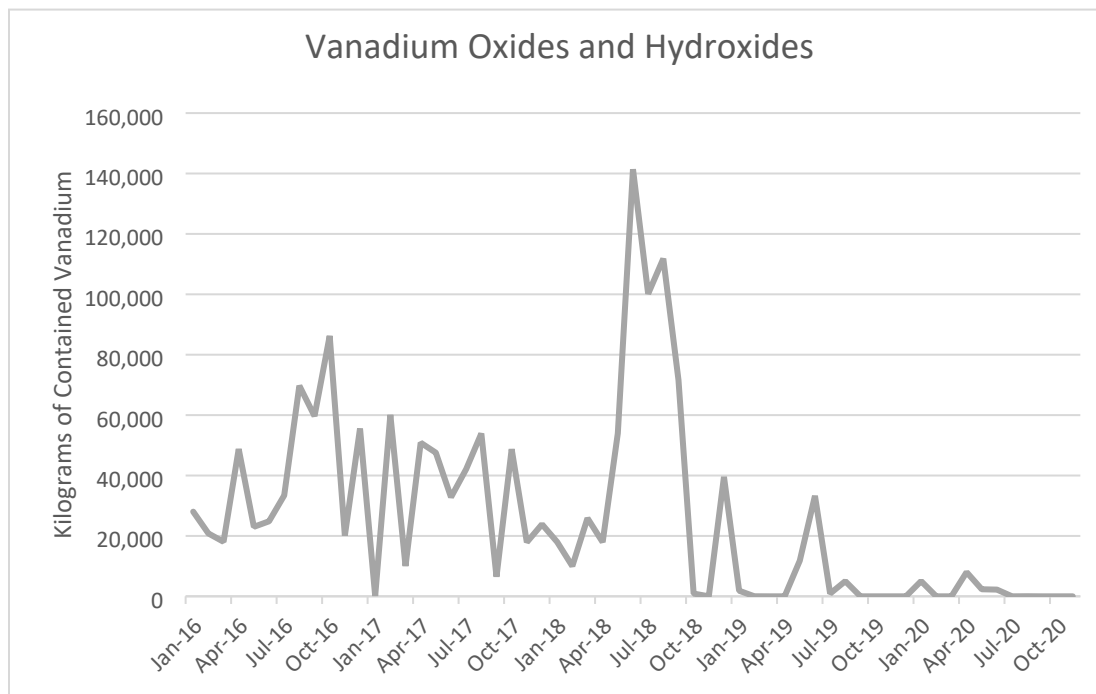
Antidumping duties on ferrovanadium add significantly to the rates for ferrovanadium from China, South Africa, and Korea (see Figure 14).

| Figure 14: Antidumping Duties on Ferrovanadium | | |
|---|--|--------------|
| Country | Exporter/Producer | Dumping Rate |
| China | Pangang Group International Economic & Trading Corporation | 12.97% |
| | China-Wide | 66.71% |
| South Africa | Highveld Steel and Vanadium Corporation, Ltd | 116.00% |
| | Xstrata South Africa (Proprietary) Limited | 116.00% |
| | All Others | 116.00% |
| Korea | Korvan Ind. Co., Ltd. | 3.22% |
| | Fortune Metallurgical Group Co., Ltd. | 54.69% |
| | Woojin Ind. Co., Ltd. | 54.69% |
| | All Others | 3.22% |
| Source: Federal Register; 68 FR 4168, 68 FR 4169, 82 FR 14874 | | |

In addition to the above general and antidumping duties, China has been subject to Section 301 duties on all subject vanadium products except HTSUS 2620.40.0030 (ash and residue containing mainly aluminum and vanadium-bearing materials) of 10% starting September 21, 2018 and 25% starting August 20, 2019. Prior to the imposition of Section 301 duties, vanadium oxides was the only category of vanadium product with significant imports from China. Imports of vanadium via vanadium oxides fell from a monthly average of 31,500 kilograms in the year prior to the initial announcement of Section 301 tariffs to 7,200 kilograms per month in year following the imposition of tariffs. Between the initial announcement of Section 301 duties in April 2018 and the imposition of duties on vanadium products in September 2018, imports of vanadium oxides from China rose to 96,000 kilograms of contained

vanadium per month, perhaps due to companies increasing inventories in anticipation of duties (see Figure 15).

**Figure 15: Imports of Vanadium Oxides and Hydroxides from China
(in kilograms of contained vanadium)**



Source: ITC Dataweb, HTS 2825.30

VII. Findings

A. Vanadium is Essential to U.S. National Security

1. Vanadium is Considered a Critical Mineral

Vanadium is one of the 35 minerals included by the Department of Interior (DOI) on the Critical Minerals List. This list, which President Trump directed DOI to define in E.O. 13817, includes minerals which meet the following criteria:

- (i) A non-fuel mineral or mineral material essential to the economic and national security of the United States,
- (ii) the supply chain of which is vulnerable to disruption, and

- (iii) that serves an essential function in the manufacturing of a product, the absence of which would have significant consequences for our economy or our national security.¹⁰³

In its report, *Critical mineral resources of the United States—Economic and environmental geology and prospects for future supply*, USGS observed that vanadium is used in steel alloys which are in turn used in critical sectors including bridges, pipelines, ships, rail cars, truck bodies, and military vehicles, and is “irreplaceable for its role in aerospace applications” via titanium alloys.¹⁰⁴ For this reason among others, and based on input from other U.S. government agencies, USGS included vanadium on the critical minerals list.

As discussed in Section V of this report, in addition to its use in alloys, vanadium is a vital component in the production of vanadium redox flow batteries (VRBs), chemical catalysts, ceramics, electronics, and other vanadium chemicals. VRBs are a potential area of large scale energy storage, a fast-growing sector that will help support the growth and reliability of the power grid. As noted above, sulfuric acid’s wide array of manufacturing uses means its production is highly correlated with industrial development. Though a small percentage of overall vanadium demand, these catalyst uses are essential for multiple critical infrastructure and commercial sectors.

USGS cited continued need for steel products as a driver of vanadium demand, specifically noting expansion of Chinese demand, increased vanadium content in steel rebar in China and Japan, growing steel production in India, and expansion of energy uses of vanadium. As a result, USGS predicts that new sources of vanadium and more efficient extraction from

¹⁰³ White House, “Presidential Executive Order on a Federal Strategy to Ensure Secure and Reliable Supplies of Critical Materials”, (December 20, 2017), <https://trumpwhitehouse.archives.gov/presidential-actions/presidential-executive-order-federal-strategy-ensure-secure-reliable-supplies-critical-minerals/>

¹⁰⁴ Kelley, K.D., Scott, C.T., Polyak, D.E., and Kimball, B.E., 2017, Vanadium, chap. U of Schulz, K.J., DeYoung, J.H., Jr., Seal, R.R., II, and Bradley, D.C., eds., *Critical mineral resources of the United States—Economic and environmental geology and prospects for future supply*: U.S. Geological Survey Professional Paper 1802, p. U1–U36, <https://doi.org/10.3133/pp1802U>.

existing sources will be required to supplement the current limited supply. Further, as vanadium is required for the manufacture of titanium products and is a significant alloying agent in high strength steel, limited vanadium production capacity could create a supply bottleneck. Such a bottleneck is one of the “vulnerabilities” identified in E.O. 13817.¹⁰⁵

2. Vanadium is Required for National Defense Systems

Vanadium, as a result of its use in steel and titanium alloys, is a critical input to many defense systems. The 2017 and 2019 Department of Commerce Section 232 reports on the effects of steel and of titanium sponge on national security found that those metals were required for national defense. Therefore, because vanadium is frequently used in these metals and there is no suitable substitute for vanadium in many of these products, vanadium is also required to meet national defense needs.

DLA has identified [TEXT REDACTED] defense systems that require the use of vanadium, including but not limited to the [TEXT REDACTED]. The average titanium content for military airframes that entered service after 2000 is 30%, implying vanadium content of roughly 1% by weight.¹⁰⁶ For example, each F-22A Raptor aircraft contains at least six separate titanium alloys, some containing as much as 15% vanadium by weight, with a finished aircraft containing approximately 9,000 pounds of titanium.¹⁰⁷ Building each aircraft requires significantly more material: about 50 metric tons of titanium, which in turn requires approximately 2 metric tons of vanadium content based on a standard Ti-6Al-4V alloy.¹⁰⁸ The F-35 Lightning II requires an estimated 15 tons of titanium per plane to build.¹⁰⁹ Overall, defense

¹⁰⁵ White House, “Presidential Executive Order on a Federal Strategy to Ensure Secure and Reliable Supplies of Critical Materials”.

¹⁰⁶ U.S. Department of Commerce. Bureau of Industry and Security. *The Effect of Imports of Titanium Sponge on the National Security* (Washington, DC: 2019) (“Titanium Report”) and based on use of standard Ti-6Al-4V alloy.

¹⁰⁷ Cotton, James D. et al. Titanium Alloys on the F-22 Fighter Airframe. *Advanced Materials & Processes*, May 2002. <https://www.asminternational.org/documents/10192/1756963/amp16005p025.pdf/c0972040-8169-4998-8699-f051fab52d9b/AMP16005P025>

¹⁰⁸ Seong, Somi et al. Titanium: Industrial Base, Price Trends, and Technology Initiatives, 2009. https://www.rand.org/content/dam/rand/pubs/monographs/2009/RAND_MG789.pdf

¹⁰⁹ Ibid.

uses account for an estimated 10% of titanium demand, equivalent to approximately 43 tons of vanadium content per year.¹¹⁰

The Department's 2018 Steel Report aligns with this finding. The report found that the Department of Defense has "a large and ongoing need for a range of steel products that are used in fabricating weapons and related systems for the nation's defense." Among the defense steel uses cited were aircraft carriers, submarines, and tanks, as well as the high-strength steel alloys used on aircraft and discussed above. The Steel Report indicated that Department of Defense's steel requirements amount to 3% of annual overall U.S. steel production, equivalent to approximately 230 metric tons of vanadium content per year.¹¹¹ In addition to direct incorporation of vanadium into defense systems, the production of these systems relies on vanadium-containing infrastructure, as tool steels and high speed steels often have a significantly higher vanadium content than other steel.

3. Vanadium is Required for Critical Infrastructure

As with national defense systems, vanadium is a key component of much of the steel and titanium used in U.S. critical infrastructure. Vanadium is a key feature in high-strength, low-alloy (HSLA) steel products used in the construction industry, including earthquake-resistant rebar, bridges, and construction cranes. Hand tools and high-speed steel tools for cutting and boring commonly contain vanadium as a strengthening agent. The commercial aerospace industry also relies on vanadium through its use of titanium alloys, and the chemical production industry uses vanadium directly for production of sulfuric acid.

The Department's 2018 Steel Report determined that 54 million metric tons of steel per year were consumed in critical industries, accounting for half of all domestic steel

¹¹⁰ Based on average annual 2016-2019 USGS vanadium apparent consumption of 8,590 tons, titanium uses accounting for 5% of vanadium consumption, and defense use accounting for 10% of titanium demand

¹¹¹ Based on average annual 2016-2019 USGS vanadium apparent consumption of 8,590 tons, steel uses accounting for 90% of vanadium consumption, and defense use accounting for 3% of steel demand

consumption.¹¹² Steel had uses in all of the United States' 16 critical infrastructure sectors, with the transportation, energy, and water treatment sectors specifically noted as vulnerable to disruption. A conservative estimate of the use of vanadium in critical infrastructure via steel products amounts to 3,865 tons of vanadium demand annually.¹¹³

In the titanium industry, nearly all vanadium-bearing titanium products have end-uses in critical infrastructure and defense sectors. Beyond the 10% of titanium consumed via military uses, an estimated 55% of consumption is in commercial aerospace products—part of the transportation critical infrastructure sector—with nearly all remaining consumption in industrial or medical uses. Use of vanadium in critical infrastructure via titanium products thus amounts to between 236 tons and 365 tons per year.¹¹⁴

Nearly all non-metallurgical uses of vanadium are also related to critical infrastructure. The energy sector is a primary destination; vanadium is used as a catalyst in industrial power plants and as the electrolyte in vanadium redox flow batteries. The other significant non-metallurgical use is in the chemical production sector, where vanadium is used as a catalyst in the production of sulfuric acid and maleic anhydride. With non-metallurgical use accounting for an estimated 5% of vanadium demand, direct vanadium use in critical infrastructure amounts to approximately 430 tons per year.¹¹⁵

With indirect use in all 16 critical infrastructure sectors, direct use in the energy and chemical production sectors, and an “irreplaceable” status in titanium alloys used in the

¹¹² Based on the 16 designated critical infrastructure sectors identified pursuant to Presidential Policy Directive 21 (PPD-21). <https://www.cisa.gov/critical-infrastructure-sectors>

¹¹³ Based on average annual 2016-2019 USGS vanadium apparent consumption of 8,590 tons, steel uses accounting for 90% of vanadium consumption, and critical infrastructure use accounting for 50% of steel demand. Use is likely higher, as critical infrastructure sectors are more likely to use HSLA and full alloy steels.

¹¹⁴ Based on average annual 2016-2019 USGS vanadium apparent consumption of 8,590 tons, titanium uses accounting for 5% of vanadium consumption, and critical infrastructure use accounting for between 55% and 85% of titanium demand; commercial aerospace estimated at 55% of titanium demand, but up to 85% of vanadium-alloyed titanium demand, with industrial and medical titanium commonly unalloyed

¹¹⁵ Based on average annual 2016-2019 USGS vanadium apparent consumption of 8,590 t

transportation sector, vanadium has a key role in U.S. critical infrastructure. Overall annual critical infrastructure use of vanadium amounts conservatively to 4,542 tons.

4. Vanadium Has Significant Effects on Other Critical Industries

As discussed above, vanadium has essential uses in steel and titanium production, and vanadium resources in the United States are often co-located with uranium. Titanium and uranium have been identified as critical minerals by the Department of Interior, with steel, titanium sponge, and uranium all the subjects of recent Section 232 investigations. The impact of the vanadium industry on other critical industries is significant, underscoring vanadium's status as a critical commodity.

Following the Section 232 investigation into the effect of imports of steel products on national security, on March 8, 2018, the President issued a proclamation concurring with the Secretary of Commerce's finding that imports of steel articles threatened to impair U.S. national security, and imposing a 25% tariff on imports. The goal of the tariff was to help ensure the economic viability of the domestic steel industry, which was threatened by low-cost imports. The basis for the President's actions, and the Secretary's findings, was the critical role of the steel industry in national security.

As discussed above, the steel industry accounts for approximately 90% of the U.S. demand for vanadium.¹¹⁶ Compared to the estimated \$92 billion worth of raw steel produced in the United States in 2019, vanadium costs constituted only a small expense for the overall industry. However, certain industry sectors incurred far higher cost exposure to vanadium. In an industry threatened by low-cost imports, even minor cost changes can have significant effects on domestic producers. Domestic producers challenged by low-cost imports for more than one essential "ingredient" for their product (e.g., steel and vanadium) face even more daunting odds.

¹¹⁶ Equivalent to 7,731 tons contained vanadium, valued at \$297 million based on U.S. Geological Survey Vanadium Mineral Commodity Summary, apparent consumption and average vanadium pentoxide prices

Aside from steel, the primary use of vanadium is for use in titanium alloys. In March 2019, following a petition from Titanium Metals Corporation (TIMET), the Department of Commerce initiated a Section 232 investigation into the effect of imports of titanium sponge on U.S. national security. The Secretary's report found that imports of titanium sponge and scrap depressed U.S. prices and constituted a threat to national security, but did not recommend adjustment of imports, favoring other measures. The President issued a proclamation on February 27, 2020 concurring with the Secretary's finding.¹¹⁷ In preparing its report, the Department found that an area of particular concern for the U.S. titanium industry is the advance of Russian and Chinese producers in aerospace-quality titanium product capabilities.

The President's February 2020 proclamation also directed the formation of a working group to ensure U.S. access to titanium sponge. Since its formation, the Titanium Sponge Working Group (TSWG) has explored measures that may help to ensure access to titanium sponge for U.S. national defense and critical infrastructure purposes. The TSWG, co-led by the Departments of Commerce and Defense, is considering a series of recommendations to move toward this goal. [TEXT REDACTED].

Accounting for approximately 5% of domestic vanadium demand, the U.S. titanium industry consumes an estimated 430 tons of contained vanadium annually, valued at \$17 million.¹¹⁸ As noted in above, in a standard Ti-6Al-4V alloy, vanadium makes up 4% of the weight and between 12 and 14% of the product cost, making the titanium industry relatively exposed to vanadium cost changes.

In the United States, primary vanadium production is currently performed only in conjunction with uranium mining. The only company to produce mined vanadium in the United

¹¹⁷ Memorandum on the Effect of Titanium Sponge Imports on the National Security. Available at <https://trumpwhitehouse.archives.gov/presidential-actions/memorandum-effect-titanium-sponge-imports-national-security/>

¹¹⁸ Based on U.S. Geological Survey Vanadium Mineral Commodity Summary, apparent consumption and average vanadium pentoxide prices

States in recent years, Energy Fuels, was one of the applicants in the Section 232 investigation into the effect of imports of uranium on national security. The Section 232 report on uranium was completed and sent to the President in April 2019. In his report, the Secretary found that uranium was being imported in such quantities and under such circumstances as to threaten to impair national security.

The President's responsive proclamation, issued in July 2019, expressed concern about domestic uranium supplies and directed the establishment of a Nuclear Fuel Working Group (NFWG) to carry out a "comprehensive review of the entire domestic nuclear supply chain."¹¹⁹

In April 2020, the Secretary of Energy announced the NFWG's findings and recommendations in a *Strategy to Restore American Nuclear Energy Leadership*. The Strategy recommended "taking immediate and bold action to strengthen the uranium mining and conversion industries."¹²⁰ The report also cited the inclusion in the President's Fiscal Year 2021 Budget Request of \$150 million for a domestic uranium reserve. The Fiscal Year 2021 Budget passed by Congress included \$75 million for establishment of a uranium reserve.

As demonstrated by the comments submitted by several companies with uranium mining resources in response to the Notice of Request for Public Comments on Section 232 National Security Investigation of Imports of Vanadium, industry sees a clear connection in the critical nature of vanadium and uranium. For example, Energy Fuels submitted a comment supporting a recommendation for Section 232 relief for vanadium, in part on the basis that there was "significant uncertainty" about a successful outcome for implementation of the NFWG's

¹¹⁹ Memorandum on the Effect of Uranium Imports on the National Security and Establishment of the United States Nuclear Fuel Working Group. <https://trumpwhitehouse.archives.gov/presidential-actions/memorandum-effect-uranium-imports-national-security-establishment-united-states-nuclear-fuel-working-group/>

¹²⁰ Department of Energy, Secretary Brouillette Announces The Nuclear Fuel Working Group's Strategy To Restore American Nuclear Energy Leadership. April 23, 2020. <https://www.energy.gov/articles/secretary-brouillette-announces-nuclear-fuel-working-groups-strategy-restore-american>

recommendations.¹²¹ Energy Fuels also wrote that vanadium relief “together with a reasonable uranium price” would enable the company to mine both uranium and vanadium in the future. Another uranium mining company, Nuvemco, LLC, submitted a comment that included their submission to the NFWG, based on the adjacency of the two mining sectors in the United States.

B. Imports of Vanadium Have Mixed Effects on the Economic Welfare of the U.S. Vanadium Industry

1. The U.S. is Presently Reliant on Imports of Vanadium

Though the scope of this investigation covers 12 discrete 10-digit HTS codes, the bulk of the vanadium imported into the United States consists of just two products: vanadium pentoxide and ferrovanadium. The third most frequently imported vanadium product is carbides, a product sector heavily dominated by South Africa exports of vanadium carbide nitride, which is used as an alternative to ferrovanadium in steel production. The remaining vanadium products imported into the United States that are covered under the scope of this investigation either constitute niche application areas or are used as inputs or feedstock in order to produce vanadium products.

| Figure 16: U.S. Imports of Vanadium Products, 2017-2020 (in millions of USD) | | | | | |
|---|---|-------------|-------------|-------------|-----------------------------|
| HTSUS | Description | 2017 | 2018 | 2019 | 2020 (Projected) |
| 7202.92.0000 | Ferrovanadium | \$94.60 | \$232.65 | \$167.90 | \$56.65 |
| 2825.30.0010 | Vanadium pentoxide (anhydride) | \$60.32 | \$168.95 | \$109.92 | \$36.90 |
| 2849.90.5000 | Carbides, whether or not chemically defined, nesoi* (excluding of boron, of chromium, or of tungsten) | \$49.38 | \$90.84 | \$98.89 | \$27.57 |
| 2620.99.1000 | Ash & residues (except from the manufacture of iron or steel), containing mainly vanadium | \$14.51 | \$63.90 | \$54.48 | \$0.48 |
| 8112.99.2000 | Vanadium and articles thereof, wrought, waste and scrap, powders, nesoi | \$10.75 | \$17.22 | \$17.64 | \$6.08 |
| 2620.40.0030 | Ash and residues (other than from the manufacture of iron or steel), containing mainly aluminum, vanadium-bearing materials | - | - | \$4.29 | \$9.99 |
| 2841.90.1000 | Vanadates,(vanadium content) | \$6.24 | \$17.46 | \$3.26 | \$2.04 |
| 2615.90.6090 | Vanadium ores and concentrates | \$0.28 | \$8.45 | \$9.49 | \$0.54 |
| 2825.30.0050 | Vanadium oxides and hydroxides, except vanadium pentoxide, nesoi | \$3.68 | \$5.45 | \$6.84 | \$3.02 |
| 8112.92.7000 | Vanadium and articles thereof, unwrought, powders, except waste and scrap | \$2.60 | \$2.21 | \$4.10 | \$0.07 |

¹²¹ Energy Fuels Resources (USA) Inc. Comment in response to Notice of Request for Public Comments on Section 232 National Security Investigation of Imports of Vanadium, July 20, 2020.
<https://www.regulations.gov/document?D=BIS-2020-0002-0016>

| | | | | | |
|---|---|----------|----------|----------|----------|
| 2850.00.2000 | Hydrides, nitrides, azides, silicides and borides, whether or not chemically defined, of vanadium | \$1.08 | \$0.92 | \$0.85 | \$0.65 |
| 2833.29.3000 | Vanadium sulfate | \$0.05 | \$0.12 | \$0.62 | \$0.27 |
| Total | Total | \$243.49 | \$608.17 | \$478.28 | \$144.26 |
| Source: ITC Dataweb, 2020 data through November | | | | | |
| *nesoi indicates “not elsewhere specified or indicated” | | | | | |

Any measurement of the United States’ reliance on imports of vanadium must take into account the wide array of vanadium products and end uses. U.S. vanadium import reliance varies depending on the type of vanadium product. Additionally, because some vanadium products are used to produce other vanadium products, import reliance calculations must consider domestic capabilities for both the vanadium end products and their vanadium-bearing feedstocks.

Domestic production capabilities exist for ferrovanadium (50% and 80%), vanadium oxides and hydroxides (including regular grade and high purity vanadium pentoxide), vanadates, vanadium ore and concentrates, vanadium master alloys, and vanadium sulfates. The United States does not currently have domestic capability for vanadium carbides (HTS 2849.90.5000) or vanadium hydrides, sulfides, nitrides, azides, silicides, and borides (HTS 2850.00.2000), [TEXT REDACTED].¹²² The United States has very limited capacity to produce vanadium ore and concentrates, with recent production intermittent and linked to uranium production.

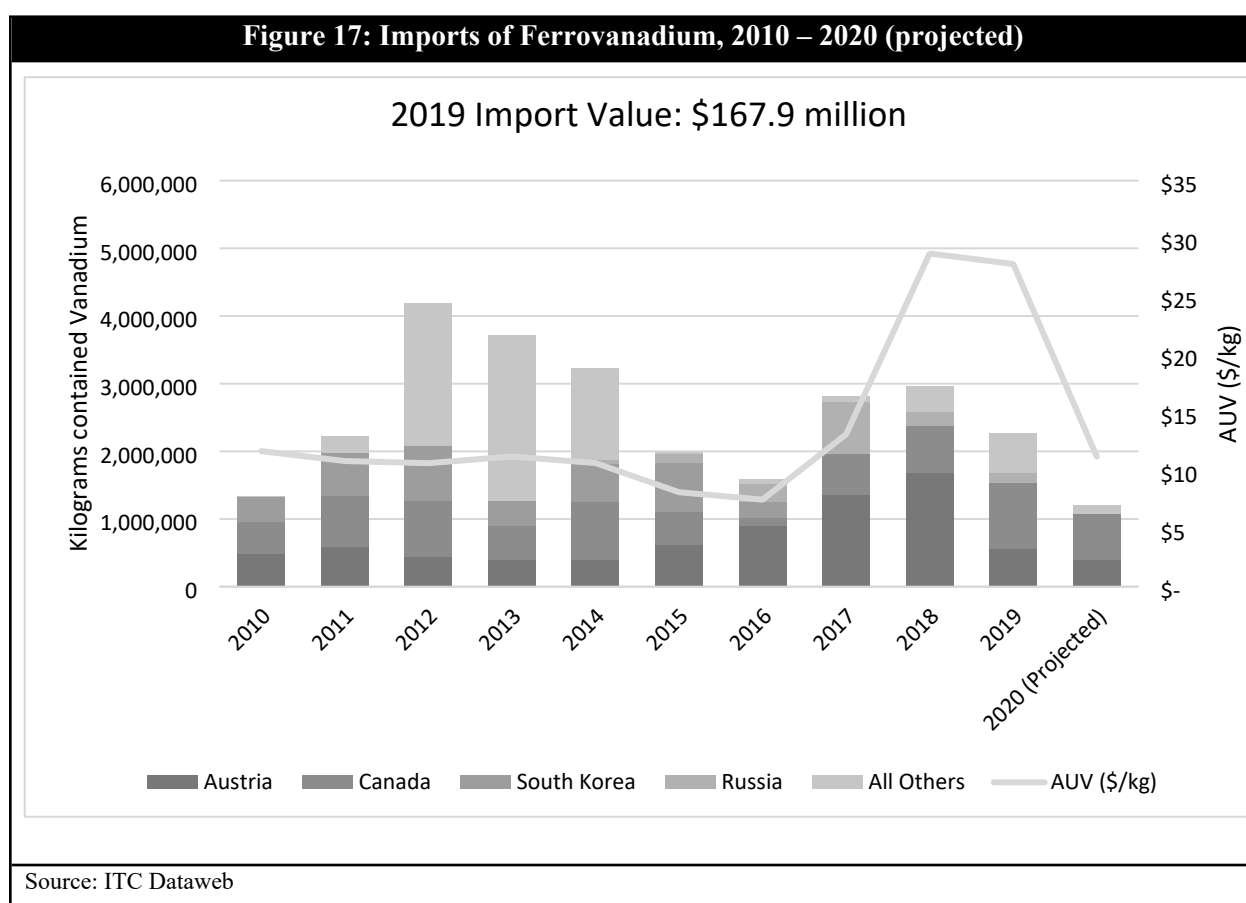
The following import analysis focuses primarily on ferrovanadium and vanadium pentoxide, recent import trends for these products and their feedstocks, and the United States’ reliance on imports to satisfy domestic demand.

Ferrovanadium

Ferrovanadium imports to the United States have fluctuated significantly in the past decade, generally tracking higher prices with lower imports, with sources increasingly

¹²² U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey.

concentrated in Europe and Canada (see Figure 17). In 2019, the last year for which full data is available, the United States imported roughly 2.3 million kilograms of contained vanadium of ferrovanadium, from Canada (43%), Austria (25%), Russia (6%) and others (26%). These imports accounted for approximately [TEXT REDACTED] of total U.S. demand for ferrovanadium in 2019, with the remaining demand filled by the domestic ferrovanadium producer AMG Vanadium and converter Bear Metallurgical. Import reliance fluctuated between [TEXT REDACTED] from 2016 to 2019, averaging roughly [TEXT REDACTED] over the period.¹²³



¹²³ Data from U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey. U.S. ferrovanadium producers produced and sold enough material to satisfy an average of [TEXT REDACTED] of apparent domestic consumption between 2016 and 2019. The U.S. exported an average of 373,154 kilograms of contained vanadium in ferrovanadium each year, resulting in domestic production filling approximately [TEXT REDACTED] of domestic demand.

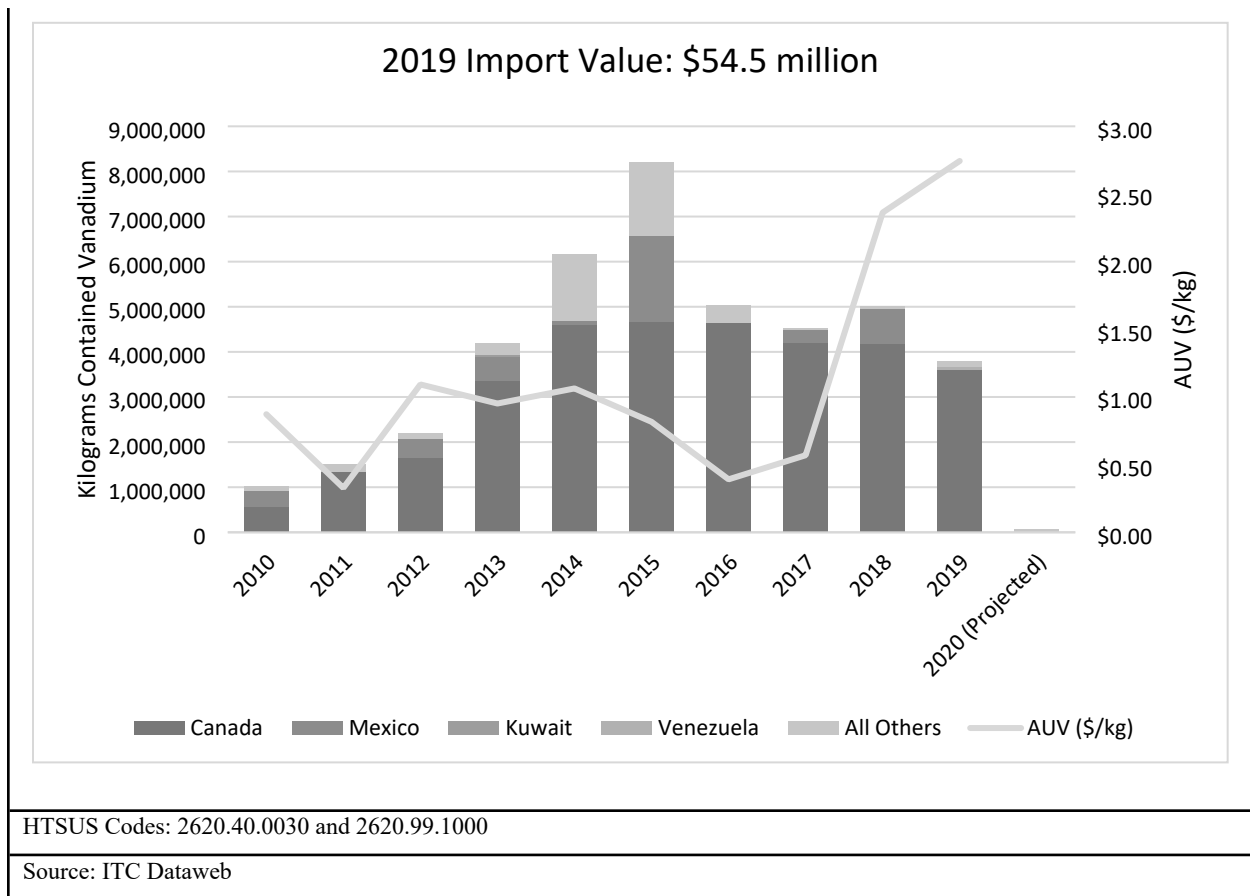
While the United States' two domestic producers of ferrovanadium have produced and sold enough material to satisfy [TEXT REDACTED] of U.S. demand from 2016 to 2019, the companies' operations require sourcing vanadium-bearing feedstock in order to produce ferrovanadium. These U.S. producers convert either vanadium-bearing waste products (ash, residues, and spent catalysts) or vanadium pentoxide in order to produce ferrovanadium. Therefore, in order to fully capture the U.S.'s level of reliance on imports for ferrovanadium, U.S. ferrovanadium producers' reliance on imported feedstock must be taken into account.

Ash, Residues, and Spent Refinery Catalyst Feedstock for Ferrovanadium Production

AMG Vanadium, one of the U.S.'s two current producers of ferrovanadium, produces ferrovanadium by recycling spent refinery catalysts. Between 2016 and 2019, the [TEXT REDACTED].¹²⁴ In 2019, U.S. imports of vanadium-bearing waste product were almost exclusively sourced in Canada, with Mexico as the primary other source since 2010, [TEXT REDACTED]. (See Figure 18).

Figure 18: Imports of Vanadium-Bearing Waste, 2010 – 2020 (projected)

¹²⁴ U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey



[TEXT REDACTED].¹²⁵ [TEXT REDACTED]. However, the company's initiative to double its production capacity (via the opening of a new facility) means that the company will soon have the ability to [TEXT REDACTED]. [TEXT REDACTED].¹²⁶

Vanadium Pentoxide Feedstock for Ferrovandium Production

Another feedstock source used to produce ferrovanadium is vanadium pentoxide. Evergreen Metallurgical (dba Bear Metallurgical (Bear)) operates a Pennsylvania facility that converts customer-provided vanadium pentoxide into ferrovanadium with 80% vanadium content (FeV-80). Bear does not source its own vanadium pentoxide, but instead acts as a service provider by toll-producing vanadium pentoxide into FeV-80 for customers. Since the idling of

¹²⁵ U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey

¹²⁶ Ibid.

the only U.S. facility that produces regular grade vanadium pentoxide (less than 99% purity), Bear has been heavily reliant on imported vanadium pentoxide feedstock from its customers.¹²⁷ That facility was owned by Bear's parent (Gulf Chemical) prior to their bankruptcy and the idling and sale of the facility in 2017 to Gladieux.

Therefore, although Bear's conversion of vanadium pentoxide into ferrovanadium satisfied approximately [TEXT REDACTED] of total U.S. demand for ferrovanadium between 2016 and 2019, the company [TEXT REDACTED].¹²⁸

In summary, while domestically-produced ferrovanadium was sufficient to meet approximately [TEXT REDACTED] of total domestic demand for ferrovanadium from 2016 to 2019, both domestic ferrovanadium producers [TEXT REDACTED].

The following section addresses U.S. import trends for vanadium oxides and hydroxides, including regular grade vanadium pentoxide, high purity vanadium pentoxide, and other vanadium oxides and hydroxides. These products are used in Bear's ferrovanadium conversion activities as well as in the company's production of vanadium products used for chemical and aerospace applications.

Vanadium Oxides and Hydroxides

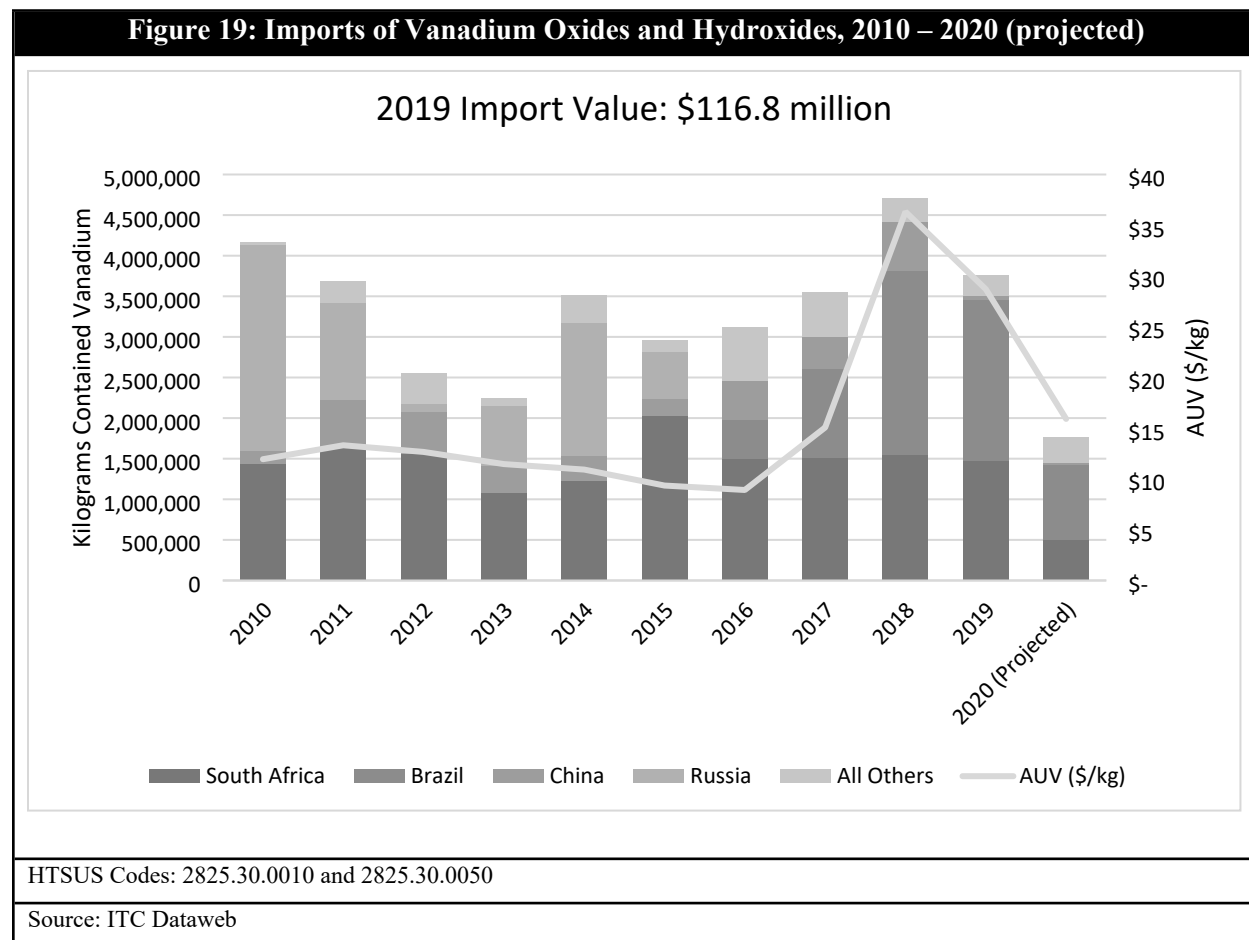
Demand for vanadium oxides and hydroxides—driven by vanadium pentoxide—accounts for close to half of all vanadium demand in the United States. On average, imports of vanadium pentoxide account for over 90% of all oxide imports each year.¹²⁹ Since 2010, overall vanadium

¹²⁷ Gladieux Metals Recycling (GMR) owns a Freeport, Texas facility that converted vanadium-bearing waste products (spent catalysts) into vanadates and vanadium pentoxide (including high purity vanadium pentoxide). The facility was in operation until 2017 when it was idled and sold to new ownership from previous owners Gulf Chemical & Metallurgical Corp. Gladieux has not produced and sold any material since 2017, but is in the process of upgrading the facility, and plans to restart [TEXT REDACTED] U.S. Vanadium operates a facility that produces high purity vanadium pentoxide, typically used in titanium or chemical uses rather than ferrovanadium production.

¹²⁸ U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey

¹²⁹ ITC Dataweb

oxide and hydroxide imports, including imports of vanadium pentoxide, have ranged between 2 million and 4.5 million kilograms of contained vanadium (imports in 2020 are projected to fall below two million, the lowest level since 2009) (see Figure 19). Between 2010 and 2015, Russian-sourced oxides and hydroxides were a major portion of U.S. imports, accounting for nearly 35% of imports, but were largely replaced by growing imports from Brazil and South Africa beginning in 2016.



Russian ferrovanadium, which had been absent from the U.S. market from 1997, returned to U.S. markets in 2014 following the October 2011 revocation of the antidumping order. Imports of Russian vanadium oxides have been largely replaced by imports of Russian ferrovanadium, though not at levels approaching the 2010 to 2014 period.

Vanadium oxides and hydroxides cover a range of vanadium products with different application areas. A nuanced measurement of the U.S.'s import reliance for this category of goods must take into account each type of product within the category, including regular grade vanadium pentoxide, high purity vanadium pentoxide, and other oxides and hydroxides.

Vanadium Pentoxide

Vanadium pentoxide can generally be divided into high purity (suitable for use in the chemical and titanium industries) and regular purity (more commonly converted to ferrovanadium for use in the steel industry). No domestic producers are currently producing regular purity vanadium pentoxide, though Gladioux is planning to restart production [TEXT REDACTED]. With Gladioux's facility idled since 2016, the U.S. has been close to 100% reliant on imports for regular grade vanadium pentoxide. U.S. Vanadium is the primary domestic producer of high purity vanadium pentoxide; Energy Fuels also provided small amounts in 2019.

Much of the regular purity vanadium pentoxide in the United States is converted into FeV-80 at Bear's Pennsylvania facility. With annual vanadium pentoxide imports from 2016 to 2019 averaging 3.8 million kilograms of vanadium content, and the company processing regular purity vanadium an annual average of [TEXT REDACTED] of vanadium content during this period, at least [TEXT REDACTED] of vanadium pentoxide imports were provided to Bear for conversion into ferrovanadium.¹³⁰

U.S. import reliance on vanadium pentoxide has risen significantly, from 55% in 2016 to 87% in 2017 and to close to 100% in 2018, due in part to the sole domestic producer of regular purity vanadium pentoxide (the Gulf/Gladioux facility in Freeport, Texas) idling operations in order to modernize the facility. The other major producer of vanadium pentoxide—the Hot Springs, Arkansas facility operated by EVRAZ Stratcor until its sale to U.S. Vanadium in 2019,

¹³⁰ U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey

which produces high purity vanadium pentoxide— has reportedly had a history of feedstock supply difficulties leading to production difficulties, which were exacerbated in 2017 following sanctions prohibiting imports from Venezuela.¹³¹ As a primary producer of vanadium, Energy Fuels is the only domestic entity entirely independent of foreign sources for generating vanadium pentoxide.

Energy Fuels has moderate vanadium pentoxide production capacity, producing high purity vanadium pentoxide containing 460,000 kilograms of vanadium in 2019, of which only a small portion was sold (approximately 410,000 kilograms was unsold and remained in the company's inventory). However, should vanadium prices rise, Energy Fuels has the capability to restart vanadium mining operations, with the capacity to produce [TEXT REDACTED].¹³² With Gladieux planning to resume operations and U.S. Vanadium increasing production levels of high purity vanadium pentoxide [TEXT REDACTED], direct U.S. import reliance for vanadium pentoxide will likely decrease in the future. [TEXT REDACTED]¹³³

However, because U.S. secondary producers are reliant on imports of vanadium-bearing wastes for most of their feedstock, the United States will likely continue to be dependent on foreign sources of vanadium to meet domestic demand for vanadium pentoxide.

Other Vanadium Products

While ferrovanadium and vanadium oxide products are the most heavily traded vanadium products, the United States is also reliant on imports for other vanadium products including vanadates, vanadium carbides, vanadium sulfates, and vanadium hydrides, sulfides, nitrides, azides, silicides, and borides.

¹³¹ Bushveld Minerals Limited. Comment in response to Notice of Request for Public Comments on Section 232 National Security Investigation of Imports of Vanadium, July 20, 2020.
<https://www.regulations.gov/document?D=BIS-2020-0002-0013>.

¹³² U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey

¹³³ Ibid.

Of these products, the United States has production capacity for only vanadium sulfate and vanadate production, and is completely import reliant for vanadium carbides and vanadium hydrides, sulfides, nitrides, azides, silicides, and borides.¹³⁴ Of these products, vanadium carbides comprised the largest share of trade by a significant margin during the period of study. Imports of vanadium carbides averaged \$67 million annually from 2016 to 2019, while the imports of vanadium sulfate, vanadates, and vanadium hydrides, sulfides, nitrides, azides, silicides, and borides combined averaged \$9 million annually during the same time period.¹³⁵

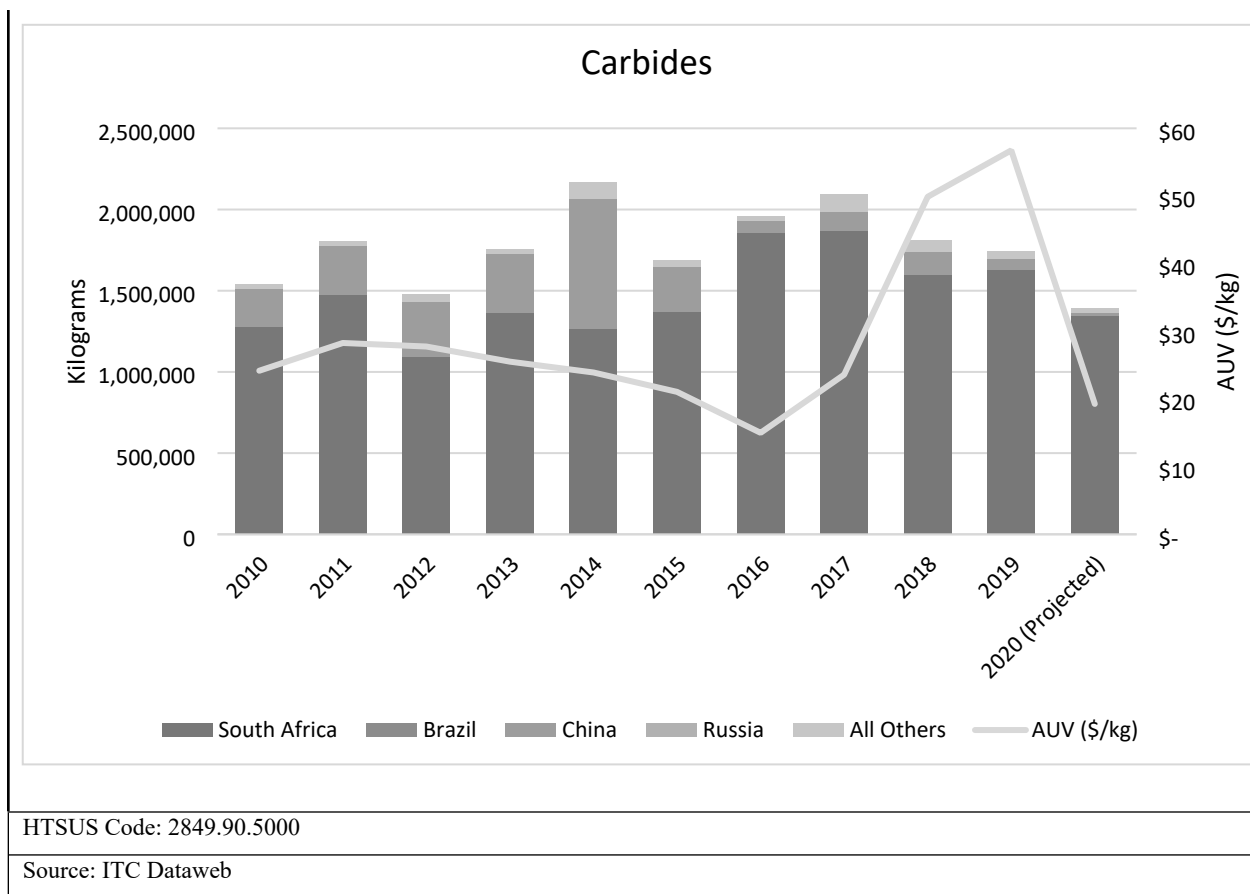
Imports of vanadium carbides, relatively stable since 2010, have come overwhelmingly from South Africa (see Figure 20). The most commonly imported carbide product is in the form of nitrided vanadium carbide sold as Nitrovan®. As noted in the USITC's 2012 antidumping report for the third sunset review on imports of ferrovanadium and nitrided vanadium from Russia, the U.S. has not produced nitrided vanadium since 1992.¹³⁶

Figure 20: Imports of Vanadium Carbides, 2010 – 2020 (projected)

¹³⁴ U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey

¹³⁵ ITC Dataweb

¹³⁶ U.S. International Trade Commission. *Ferrovanadium and Nitrided Vanadium from Russia*. Investigation No. 731-TA-702, (Third Review). https://www.usitc.gov/publications/701_731/pub4345.pdf



In summary, understanding the overall U.S. import reliance on vanadium must take into account the structure of the vanadium supply chain, including the original feedstock of the vanadium products. [TEXT REDACTED]. The United States has no producers of vanadium carbides, nor of vanadium hydrides, nitrides, azides, silicides, and borides. For the balance of vanadium products the United States is not directly import reliant, but to the extent that it is reliant on imports of vanadium feedstock and vanadium pentoxide, it is because these products depend on non-U.S. origin inputs.

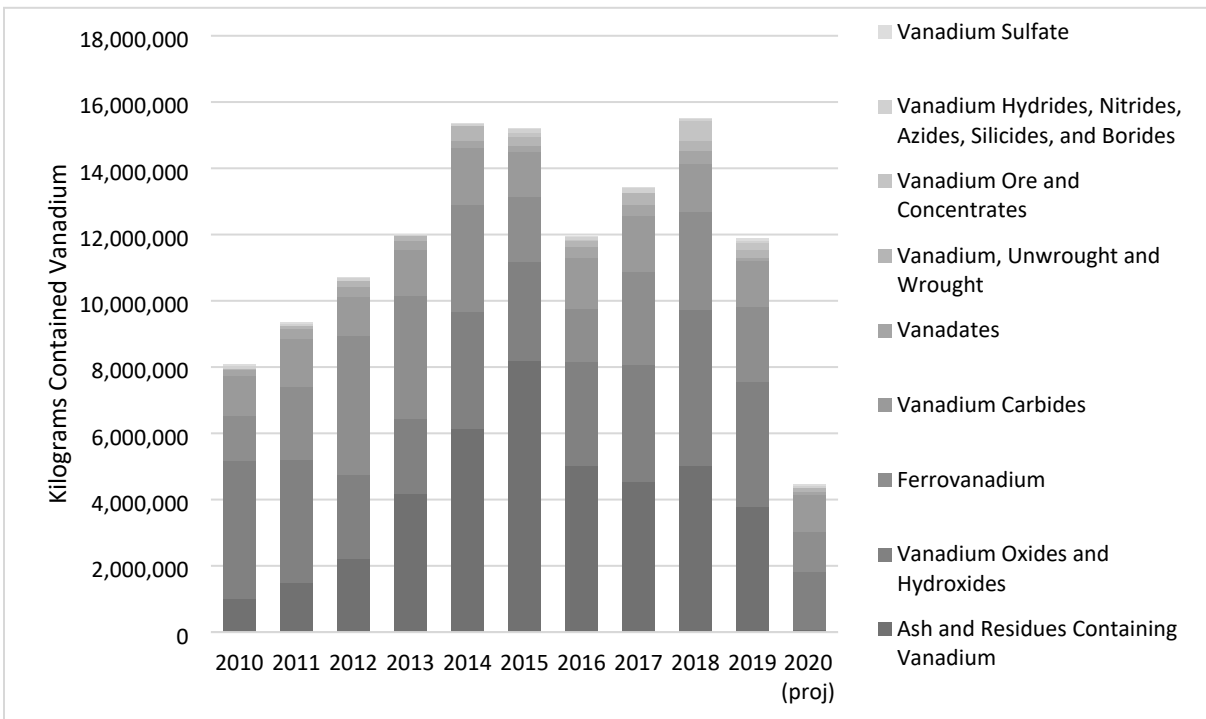
| [TEXT REDACTED] | | | | |
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| [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] |
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| [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] |
| | [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] | |
| [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] |
| [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] |
| [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] |
| [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] |
| [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] | [TEXT REDACTED] |
| [TEXT REDACTED] | | | | |

2. U.S. Reliance on Imports of Vanadium is Not Increasing

Imports of contained vanadium to the United States have not increased since 2014 and have decreased moderately since that time (see Figure 22). Even before the 2020 plunge in imports (driven by COVID-19-related demand declines), overall contained vanadium imports in 2019 were 4% below the 2010-2019 average.

Figure 22: Imports of Contained Vanadium, 2010 – 2020 (projected)



Source: ITC Dataweb

Further, import reliance is not likely to increase. Major U.S. producers of ferrovanadium and vanadium pentoxide are in the process of expanding or restarting operations. U.S. capacity for ferrovanadium production from vanadium-bearing waste will more than double in 2021 with the opening of AMG Vanadium's new facility; the production increase will exceed annual average imports of ferrovanadium. U.S. capacity for vanadium pentoxide production from vanadium-bearing waste will also [TEXT REDACTED].

However, despite these upcoming significant increases in vanadium pentoxide and ferrovanadium production capacity, the United States will remain heavily reliant on foreign sources of vanadium, as significant quantities of the feedstock that U.S. producers use are

sourced from outside the country. Mitigating factors on this reliance include that [TEXT REDACTED].¹³⁷

In addition, several mining companies with locations in the United States have idle production capacity, significant inventory, and/or are exploring the development of vanadium mines. For example, Energy Fuels retains 410,000 kilograms of vanadium in inventory from 2019 production, and has indicated the ability to produce [TEXT REDACTED].¹³⁸ The Gibellini project in Carlin, Nevada expects to receive permits in 2021 and begin production in 2023, with an annual production forecast of 2.4 million kilograms of vanadium content per year.¹³⁹ Should both of these producers achieve their full capacity, their production would equal [TEXT REDACTED] of vanadium content per year, or [TEXT REDACTED] of annual domestic demand from 2016 to 2019. An increase in the availability of domestic primary vanadium, expansion of secondary production, and the addition of domestic feedstock for secondary production would mitigate current high reliance on imports.

3. Prices

Vanadium prices have a long history of volatility, with resulting impacts on the availability of vanadium resources and the viability of vanadium producers, as well as patterns of investment. The benchmark vanadium pentoxide price has more than doubled in short spans three times since 2004, most notably rising from \$7 per pound in September 2004 to nearly \$35 per pound in May 2005 before falling to \$10 per pound by June 2006.

Such cycles may be more the standard than an anomaly in the vanadium industry. In 1977, the primary U.S. producer of vanadium oxide—Union Carbide—cut its production due to low prices and, in 1978, announced the idling of its Arkansas mine and mill.¹⁴⁰ Less than a

¹³⁷ U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey

¹³⁸ Ibid.

¹³⁹ Silver Elephant Mining Corporate Presentation: Gibellini Vanadium, <https://www.silverelephantmining.com/projects/gibellini-vanadium/>

¹⁴⁰ Bureau of Mines Minerals Yearbook, Vanadium 1977.

decade later, in 1985, the U.S. Bureau of Mines wrote that the domestic vanadium industry was in the midst of a “major restructuring ... triggered by (1) the sharp decline in ferrovanadium consumption by U.S. steel producers during the 1982-83 recession, and (2) continuing depressed prices for co-product uranium oxide.”¹⁴¹ Just four years later, they reported:

The year 1988 proved to be a boom year for vanadium producers as tight supply and strong demand by the steel industry and other consumers pushed up the price of vanadium compounds. ... By the end of 1989, vanadium’s fortunes had turned full circle as the market witnessed prices headed for levels lower than at any time since the early 1980s.¹⁴²

Price-related closures and investments have continued. The Australian Windimurra mine, for instance, closed as the result of low prices in 2003 only to be purchased by a new company when prices spiked in 2005. After an investment of more than \$100 million, prices fell and the mine was not reopened.¹⁴³ In the United States, during the latest price spike, AMG Vanadium announced the approval for construction of its new facility (in October 2018);¹⁴⁴ the owners of the Gibellini property completed its Preliminary Economic Assessment (PEA) (in May 2018); and First Vanadium carried out its maiden mineral resource classification (in February 2019).

The introduction of new capacity is tied to vanadium prices, as extraction that is not viable at \$6 per pound vanadium pentoxide can become profitable at \$12 per pound. First Vanadium’s PEA assumes a vanadium pentoxide price of \$10.65 per pound, well above current prices, and a cost of production of \$5.17 per pound.¹⁴⁵ Only [TEXT REDACTED] U.S. producers of vanadium pentoxide or vanadium ore indicate the ability to produce at current

¹⁴¹ Bureau of Mines Minerals Yearbook, Vanadium 1985.

¹⁴² Bureau of Mines Minerals Yearbook, Vanadium 1989.

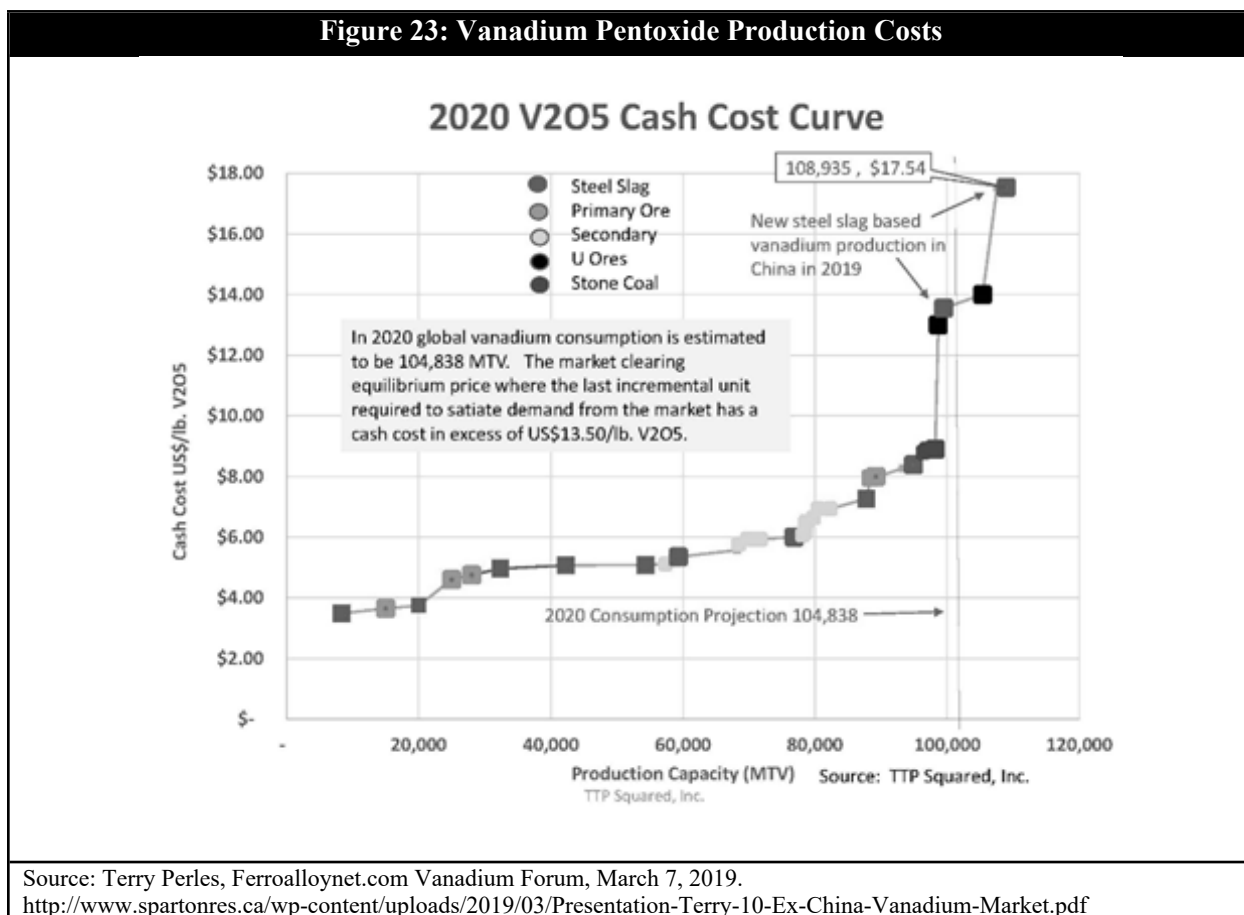
¹⁴³ McKinnon, Stuart. Vanadium Price Boom Offers Hope of Windimurra Revival. *The West Australian*, April 2, 2018. Available at <https://thewest.com.au/business/mining/vanadium-price-boom-offers-hope-of-windimurra-revival-ng-b88792684z>

¹⁴⁴ AMG ADVANCED METALLURGICAL GROUP N.V. COMPLETES FEASIBILITY STUDY TO EXPAND SPENT CATALYST PROCESSING CAPACITY . <https://amg-v.com/oct-16-18-news/>

¹⁴⁵ First Vanadium Announces Positive Preliminary Economic Assessment for the Carlin Vanadium Project in Nevada <https://www.firstvanadium.com/index.php/news/2020/548-irstanadiumnnouncesositivereliminaryconomicsse20200511>)

prices, though the number of producers rises [TEXT REDACTED] once prices increase to \$10 per pound of vanadium pentoxide and [TEXT REDACTED] at \$13 per pound.¹⁴⁶ This is consistent with the world cost curve, which shows most currently viable production operates below a cost of \$8 per pound (see Figure 23).

Figure 23: Vanadium Pentoxide Production Costs

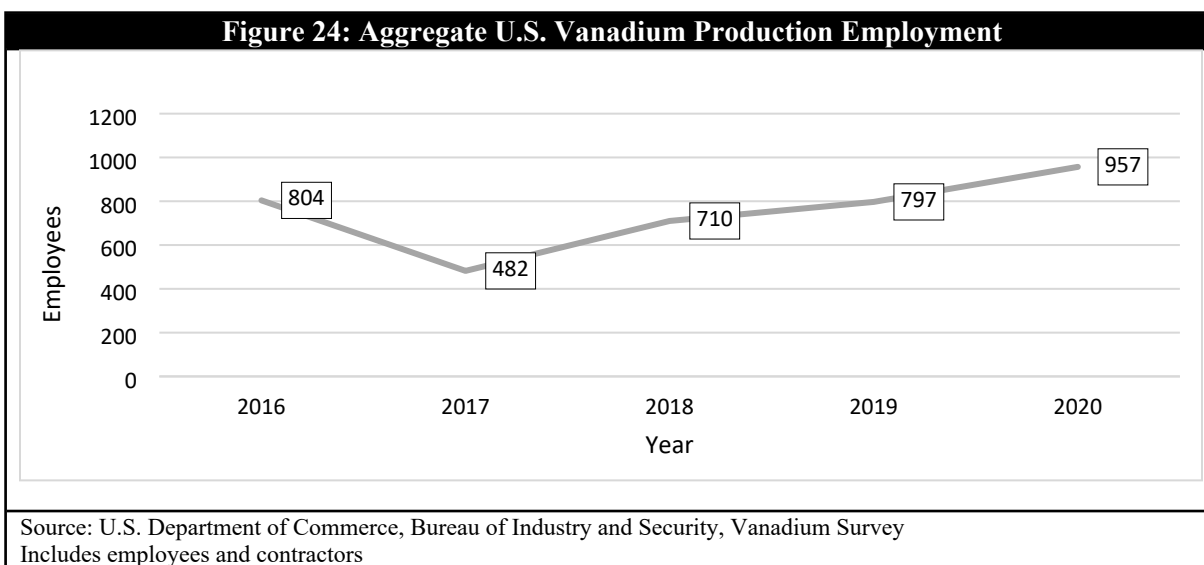


4. Employment

Although never a major employer, aggregate employment in the U.S. vanadium industry has waxed and waned during the last decade. The sector currently employs more people than it has during that time period, however, this current increase has not been shared equally across industry participants. While some producers have added employees, others have not.

¹⁴⁶ U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey

Employment levels among vanadium producers were most notably affected by the 2017 idling and ongoing refurbishment of Gladieux's Texas facility. The facility's closure caused aggregate industry employment to drop sharply in 2017 but the numbers rebounded sharply in 2018 (see Figure 24).



[TEXT REDACTED]

Most U.S. producers of vanadium products indicate that the volatility of vanadium prices make it difficult to recruit and retain employees. [TEXT REDACTED]

5. Financial Outlook

The U.S. vanadium production industry is small and in the midst of significant restructuring, making the industry's overall financial outlook difficult to characterize. However, it is clear that the industry has been significantly impacted by rapid changes in vanadium prices, particularly the collapse in price in 2019 from a high of approximately \$30 per pound of vanadium pentoxide in November 2018 to less than \$7 per pound by the end of 2019 and by the ongoing impacts of COVID-19 on the steel and titanium industries.

[TEXT REDACTED]

[TEXT REDACTED]¹⁴⁷

Given its acquisition of EVRAZ Stratcor's Arkansas facility in October 2019, it is difficult to fully assess the financial health of U.S. Vanadium, as the facility's business practices are in transition. [TEXT REDACTED]

[TEXT REDACTED]

The facility of the remaining U.S. secondary producer, Gladieux, remains idle as the company completes the extensive modernization started after Gladieux purchased the facility from Gulf Chemical in 2017. [TEXT REDACTED]

[TEXT REDACTED]

The only other company that has produced vanadium production since 2016 is Energy Fuels Resources, whose primary business line is uranium mining. [TEXT REDACTED]

[TEXT REDACTED]

6. Exploration

In addition to Energy Fuels' primary production capacity, several other companies have properties that have mined vanadium in the past or are now under exploration. However, future profitable production at any of these properties is dependent upon an increase in the price of vanadium.

Western Uranium & Vanadium [TEXT REDACTED].¹⁴⁸

¹⁴⁷ AMG Annual General Meeting Minutes (May 1, 2019), as provided in public comments by Bushveld Minerals Limited, available at <https://www.regulations.gov/document?D=BIS-2020-0002-0013>

¹⁴⁸ U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey

Nuvemco, LLC owns the Last Chance Mine in Colorado, which has been idle since 2009 but the company says can return to operations within 120 days.¹⁴⁹ [TEXT REDACTED]

Two additional projects are under development: First Vanadium Corporation's Carlin Vanadium Project and Nevada Vanadium LLC's (Nevada Vanadium) Gibellini Vanadium Project. The Gibellini project is in the permitting process, with BLM expected to reach a decision by August 2021.¹⁵⁰ Nevada Vanadium plans to begin production in late 2023, producing vanadium pentoxide with 33 million kilograms of vanadium content over 14 years.¹⁵¹ [TEXT REDACTED]

First Vanadium Corporation completed the PEA for its Carlin project in 2020, forecasting 16 years of vanadium production capabilities totaling 46 million kilograms of vanadium content.¹⁵² [TEXT REDACTED]

7. Capital Expenditures

U.S. producers of vanadium have made significant capital expenditures in the last four years, with the construction of AMG Vanadium's new Ohio facility and Gladieux's overhaul of its Texas facility at the forefront. AMG Vanadium's expansion will more than double its ferrovanadium production capacity, adding over 2.5 million kilograms per year of capacity and 100 new jobs at an estimated cost of \$200 million.¹⁵³ [TEXT REDACTED] Gladieux has

¹⁴⁹ <http://www.nuvmco.com/Projects.html>

¹⁵⁰ Bureau of Land Management Accepting Comments for Gibellini Mine, August 17, 2020. Available at <https://www.blm.gov/press-release/bureau-land-management-accepting-comments-gibellini-mine>

¹⁵¹ Silver Elephant Mining Corporate Presentation: Gibellini Vanadium, <https://www.silverelephantmining.com/projects/gibellini-vanadium/>

¹⁵² "First Vanadium Announces Positive Preliminary Economic Assessment for the Carlin Vanadium Project in Nevada", <https://www.firstvanadium.com/index.php/news/2020/548-irstanadiumnouncesositivereliminaryconomicsse20200511>

¹⁵³ AMG Vanadium Constructing a Second Ohio Plant, Investing More Than \$200 Million. <https://www.jobsohio.com/news/posts/amg-vanadium-constructing-a-second-ohio-plant-investing-more-than-200-million/>

invested more than [TEXT REDACTED] in the restart of its Texas facility, planning to open vanadium pentoxide production [TEXT REDACTED] with [TEXT REDACTED].

[TEXT REDACTED]

Among potential primary producers, [TEXT REDACTED]

8. Environmental Factors

Vanadium-bearing waste products—the primary source material for vanadium production in the United States—are classified by the EPA as hazardous wastes.¹⁵⁴ The recycling of these materials and reclamation of critical minerals constitutes an important step in both protecting human health and promoting an assured supply of critical minerals. AMG Vanadium claims a “99% conversion rate for all raw material,” and has a policy not to send spent catalyst to landfill.¹⁵⁵

However, the recycling and reclamation process is expensive and subject to fines if not implemented correctly or fully. For example, one of the causes of Gulf’s 2016 bankruptcy was the challenge and resulting costs of managing the pollutants from its Texas facility. The company spent more than \$60 million on environmental protection-related expenditures and fines between 2010 and 2016. As noted above, since Gladieux purchased the facility in 2017, it has invested more than [TEXT REDACTED] in updating the facility to “best in class” standards.

Most vanadium-bearing spent catalysts are covered by a rule published by the EPA on August 26, 1998.¹⁵⁶ That rule identifies spent catalysts from hydrotreating and hydrorefining as hazardous wastes, does not comment on spent hydrocracking catalyst. In 2002, the EPA later issued a clarification of the scope of the hazardous waste listings; as part of that rulemaking process, the agency gathered industry data on quantities of spent catalyst generated and recycled

¹⁵⁴ 63 FR 56710

¹⁵⁵ https://amg-v.com/wp-content/uploads/2019/11/The_Gold_Standard_Risk_Mitigation_Handbook_Nov_2019.pdf

¹⁵⁶ 63 FR 42110

in the United States.¹⁵⁷ This data showed that the country generated 31,313 tons of spent catalyst classified as hazardous waste in 1999, with 55% of it recycled/reclaimed. The EPA estimated the cost of reclamation at \$725 per ton, while the cost of landfilling the catalyst was \$240 per ton; low vanadium prices were cited as one potential reason for the difference in cost.

Safe processing of refinery byproducts is essential for continued oil refining in the United States. With valuable minerals contained in these waste products and human health and environmental risks stemming from their improper disposal, encouraging safe full value extraction will support the long term economic health and competitiveness of the country. However, solutions to the recycling of refinery byproducts in the United States attractive to current producers, especially while vanadium prices remain below levels that allow for profitable production, are essential.

C. Displacement of Domestically-Produced Vanadium by Imports Affects Our Internal Economy, but is Mitigated by Ongoing Actions

1. U.S. Production of Vanadium is Well Below Domestic Demand

Between 2016 and 2019, the United States produced an annual average of 3.4 million kilograms of contained vanadium from primary or secondary production while importing 7.8 million kilograms of contained vanadium in the form of ferrovanadium, vanadium pentoxide, and carbides. Production capacity in 2020 remained insufficient to meet domestic demand, with non-conversion production capacity totaling [TEXT REDACTED] of contained vanadium.

Domestic production capacity will greatly expand in the near future with AMG Vanadium's expansion in Ohio planned to open in 2021 with capacity to produce ferrovanadium with [TEXT REDACTED] from spent catalyst, and Gladieux's overhaul of their Texas facility

¹⁵⁷ <https://archive.epa.gov/epawaste/hazard/web/pdf/backdoc.pdf>

expected to be completed [TEXT REDACTED].¹⁵⁸ These additions will raise U.S. production capacity [TEXT REDACTED]. Additionally, should vanadium prices increase sufficiently, Nevada Vanadium’s Gibellini mine could begin production in 2023 with an estimated annual production level of 2.4 million kilograms of contained vanadium.¹⁵⁹

2. Domestic Production is Highly Concentrated and Limits Capacity Available for a National Emergency

There were just three companies that carried out vanadium production in 2019—AMG Vanadium, US Vanadium, and Energy Fuels—with one additional company—Gladieux—idle for renovation. [TEXT REDACTED] Several companies have undertaken major investments in vanadium production capacity in anticipation of higher prices, but should prices not increase, one or more secondary producers may face challenges to continue production and additional mine capacity is unlikely to come on line.

Producers of high purity vanadium pentoxide face particular challenges because the primary destination of their product is the titanium industry, which has been significantly impacted by the COVID-19-related drops in air travel and, accordingly, aerospace industry production. There is no clear marker for when domestic aerospace production will begin to recover. Additionally, other than the approximately 10% of industry demand from titanium and non-metallurgical uses, domestic producers of vanadium pentoxide are reliant on toll converter Bear to supply product to the steel industry. [TEXT REDACTED]

Reactivation of idle capacity is not a quick process. [TEXT REDACTED]

However, adding new capacity would take significantly longer than reactivating existing facilities. While AMG Vanadium’s new facility is projected to take about two years to complete,

¹⁵⁸ U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey

¹⁵⁹ Silver Elephant Mining Corporate Presentation: Gibellini Vanadium, <https://www.silverelephantmining.com/projects/gibellini-vanadium/>

this is a relatively short time period that reflects the company's experience and the fact that the facility under construction is similar to its existing facility. The exploration and construction of primary production facilities in the United States takes significantly longer than the secondary production facility construction illustrated by AMG Vanadium. A more typical timeline may be Nevada Vanadium's Gibellini mine—the new project most likely to receive a permit—which carried out its PEA in 2018, is expected to receive permitting from BLM in 2021, and hopes to begin production in 2023, more than five years after its PEA.

These limitations represent a threat to the continued availability of domestically produced vanadium pentoxide, as needed to support national defense and critical infrastructure needs.

3. Domestic Vanadium Production Currently Requires Significant Imports of Vanadium Feedstock, Limiting Capacity Available for a National Emergency

Vanadium production in the United States is reliant on imports of vanadium feedstock to produce all vanadium products. The only vanadium producer in recent years to use entirely U.S. origin material is primary producer Energy Fuels, which has produced 460,000 kilograms of contained vanadium since 2016, accounting for 1.4% of U.S. apparent consumption.

Secondary producers AMG Vanadium, U.S. Vanadium, and Gladioux have all historically used foreign sources of vanadium-bearing wastes to provide portions of their feedstock. [TEXT REDACTED]

Current sourcing practices leave the United States unable to meet domestic demand with U.S.-sourced material; [TEXT REDACTED]. Although Energy Fuels' 2019 production of high purity vanadium pentoxide with 460,000 kilograms of vanadium content [TEXT REDACTED] is likely sufficient to meet defense system requirements (which are estimated above at less than

300,000 kilograms of contained vanadium per year), other national security requirements cannot currently be met using only U.S.-origin vanadium.

4. Trade Actions Have Been Successful in Mitigating Artificially Low-Priced Imports of Vanadium

Of the four countries with significant primary production of vanadium, three (Russia, China, and South Africa) have been subject to the imposition of antidumping duties on ferrovanadium by the Department and the USITC. Although not a primary producer, Korea has also been subject to antidumping duties. In all cases, after the duties were imposed, imports of ferrovanadium decreased significantly.

These cases show the longstanding and repeated success of antidumping duties in countering imports of ferrovanadium products sold in the United States at less than fair value.

5. Critical Minerals Agreements Will Help Ensure Reliable Supplies of Vanadium

In June 2019 the Department issued a report, *A Federal Strategy to Ensure a Reliable Supply of Critical Minerals*. This report “outlines a coordinated approach by the Federal Government in response to Executive Order 13817 to reduce the Nation’s vulnerability to disruptions in the supply of critical minerals.” The Federal Strategy includes six calls to action, covering 24 goals and 61 recommendations, to achieve the goals put forth in E.O. 13817. One of these calls to action is “Enhance International Trade and Cooperation Related to Critical Minerals,” and recommends working with allies to ensure access to critical minerals as well as “robust enforcement of U.S. trade laws and international agreements.”¹⁶⁰

To achieve this goal, the Federal Strategy proposes that the USG establish intergovernmental agreements with partner countries, focused on ensuring continued access to

¹⁶⁰ https://www.commerce.gov/sites/default/files/2020-01/Critical_Minerals_Strategy_Final.pdf

critical minerals. The Federal Strategy recommends that the USG continue to expand cooperation and collaboration with interested parties on critical minerals issues related to:

- (1) resource identification and exploration;
- (2) processing and recycling;
- (3) mitigating supply risk and preventing supply chain disruptions;
- (4) research and development related to critical mineral materials and manufacturing and;
- (5) tracking and sharing information on foreign investment and acquisitions of mineral rights, property, and development.

Among the achievements resulting from this call to action to date are:

U.S.-Canada Joint Action Plan on Critical Minerals

In January 2020, the United States and Canada announced the finalization of the U.S.-Canada Joint Action Plan on Critical Minerals Collaboration.¹⁶¹ The plan aims to facilitate development of secure supply chains for critical minerals that are key to strategic industries. This bilateral initiative addresses concerns about reliance on other countries for the supply of minerals critical to defense, aerospace, communications, and other strategic industries.

As part of the joint action plan, Canada and the United States have identified areas for cooperation, including: (i) securing critical mineral supply chains for strategic industries and defense; (ii) improving information sharing on mineral resources and potential; (iii) engaging with the private sector; (iv) collaborating in multilateral fora and with other countries; (v) undertaking research and development initiatives; (vi) engaging in supply chain modeling; and (vii) increasing support for the metals and mining industry.

¹⁶¹ <https://www.state.gov/united-states-and-canada-finalize-action-plan-on-critical-minerals-cooperation/>

As a result of its strong political and economic ties to the United States, the shared border, its stable regulatory environment, and an abundance of mineral resources, collaboration with Canada provides the United States a path to expanded secure supplies of critical minerals, including vanadium. Although not a current producer of vanadium, Canada has several projects underway, including BlackRock Metals' Chibougamou mine, which may begin production in 2021 with planned annual production of more than 4,000 tons of vanadium, close to half the U.S.'s average annual consumption from 2016 to 2019 of 8,590 tons.

U.S.-Australia Critical Minerals Plan of Action

In November 2019, the United States and Australia formalized a partnership to collaborate on research and increase critical minerals capacity.¹⁶² The activities under the Plan of Action include focusing on resource mapping and quantitative assessments, determining geological controls on critical minerals distribution, and improving understanding of supply and demand scenarios for shared critical minerals trade between the United States and Australia.

As Australia is one of six countries in the world with USGS-recognized vanadium reserves, and has five exploration projects in advanced stages, this partnership holds significant promise to support U.S. access to reliable sources of vanadium.

D. Increased Global Capacity and Production of Vanadium Will Further Impact the Long-Term Viability of U.S. Vanadium Production

1. China Possesses an Outsized Role in the Global Price of Vanadium

China accounts for an estimated 50 to 60% of global vanadium production, with a similar level of demand. This concentration of production and consumption means that policy changes in China can have large effects on the global vanadium market. As Energy Fuels' vice president

¹⁶² <https://www.doi.gov/pressreleases/united-states-and-australia-formalize-partnership-critical-minerals>

Curtis Moore said in 2019, “the biggest driver of vanadium prices is economic and industrial policy in China, which is opaque to say the least.”¹⁶³

The spike in vanadium prices from 2017 into 2018 was largely attributed to a change in Chinese steel rebar standards to require the addition of more vanadium.¹⁶⁴ Similarly, the precipitous fall in prices following the implementation of the standard on November 1, 2018 has been linked to “enforcement of the standards not being as stringent as previously expected,” as well as the substitution of niobium for vanadium due to price increases.¹⁶⁵ Finally, Chinese vanadium pentoxide production in the first half of 2019 was 30% higher than in the first half of 2018, increasing supply more than anticipated and further driving prices down.¹⁶⁶ China’s ability to influence vanadium markets through supply, demand, and policy changes has a significant impact on the ability of companies in the United States to plan investments and production decisions.

2. Expansion of Low-Cost Production in Several Countries Will Place Downward Pressure on Global Vanadium Prices

In 2019, total production of primary- and co-produced (mine) vanadium was 73,000 metric tons. However, there are mines in development or exploration in Kazakhstan, Canada, and Australia which have the estimated capacity to add 12,408 tons of production in 2021, and

¹⁶³ Barrera, Priscili. Vanadium Outlook 2020: Is Vanadium Due for a Comeback? December 31, 2019. <https://investingnews.com/daily/resource-investing/battery-metals-investing/vanadium-investing/vanadium-outlook>

¹⁶⁴ Vanadium: Prices soar as new rebar regulations take effect. November 1, 2018. <https://roskill.com/news/vanadium-prices-soar-as-new-rebar-regulations-take-effect/>

¹⁶⁵ Radford, Charlotte and Lv, Amy. Focus: Why China’s implementation of new rebar policy is failing to support vanadium prices. December 20, 2018. <https://www.metalbulletin.com/Article/3850389/FOCUS-Why-Chinas-implementation-of-new-rebar-policy-is-failing-to-support-vanadium-prices.html>

¹⁶⁶ Lv, Amy. Oversupply to persist for China V market. August 16, 2019. <https://www.amm.com/Article/3889693/Oversupply-to-persist-for-China-V-market.html>

57,000 additional metric tons in future years, should all projects enter production.¹⁶⁷ The owners of the Kazakh mine have claimed it can operate “at the world’s lowest cash cost of production.” By contrast, mine facilities in the United States are expected to have the capacity to produce 3,100 tons of vanadium in 2021, with an additional 2,900 tons per year in exploration.¹⁶⁸ This amount would satisfy the majority of current domestic demand, but is not likely to be produced without higher vanadium prices.

In addition to primary vanadium, AMG Vanadium plans to open its new Ohio facility in 2021, with the capacity to [TEXT REDACTED].¹⁶⁹ The company is also exploring the construction of similar facilities in Saudi Arabia and China, and has noted that their recycling operations have little dependence on the cost of vanadium, with recycling fees driving profits.¹⁷⁰ The ability to generate cash flow independent of vanadium costs could result in the introduction of new capacity even at low vanadium prices. Barring significant new demand for vanadium, the addition of new sources of supply will continue to impact vanadium prices.

3. Downward Price Pressure May Be Mitigated by Increased Demand for Steel, Titanium, and Energy Storage

With the steel industry consuming approximately 90% of vanadium demand, changes in vanadium consumption are largely tied to that industry. Global steel production in 2020 was affected by the COVID-19 pandemic, and had a forecasted decline of 2.4%.¹⁷¹ Steel production in the United States saw a much larger decrease of approximately 18% from 2019.¹⁷² The

¹⁶⁷ Data from USGS, Government of Australia, BlackRock Metals, VanadiumCorp Resources, Vanadium One Iron Corporation, and Ferro-Alloy Resources Group

¹⁶⁸ Data from Energy Fuels Resources (USA), First Vanadium Corporation, and Silver Elephant Mining

¹⁶⁹ U.S. Department of Commerce, Bureau of Industry and Security, Section 232 Investigation into Imports of Vanadium Survey.

¹⁷⁰ Bushveld Minerals Limited. Comment in response to Notice of Request for Public Comments on Section 232 National Security Investigation of Imports of Vanadium, July 20, 2020. <https://www.regulations.gov/document?D=BIS-2020-0002-0013>.

¹⁷¹ Worldsteel Short Range Outlook October 2020. October 15, 2020. Available at <https://www.worldsteel.org/media-centre/press-releases/2020/worldsteel-Short-Range-Outlook-October-2020.html>

¹⁷² Data as of December 16, 2020. <https://www.steel.org/industry-data/>

declines in steel production impact vanadium prices, which had not recovered since falling from a peak of nearly \$34 per pound vanadium pentoxide in November 2018 to \$6 per pound in December 2019.¹⁷³ While steel demand, and accordingly vanadium demand, is projected to bounce back in 2021 to 4.1% growth, longer range forecasts estimate global steel demand growing at an annual rate of 1.4% through 2035.¹⁷⁴ Increased vanadium use within the steel industry, such as that resulting from implementation of the 2018 regulation in China requiring the addition of vanadium to steel rebar and increased demand for high strength and tool steel, may provide additional growth in vanadium demand, with Vanitec (a global vanadium industry association) forecasting a 30% increase in vanadium demand by 2025.¹⁷⁵

The titanium industry, with approximately 55% of demand coming from the aerospace sector, has been even more significantly affected by COVID-19 than the steel industry. Global titanium sponge production was projected to decline [TEXT REDACTED] from 2019 to 2020, with titanium shipments falling [TEXT REDACTED].¹⁷⁶ Prior to the pandemic, titanium alloy growth rates were forecasted in the 3 to 5% per year range, and expected to track closely with aircraft demand.¹⁷⁷ To the extent that the end of the pandemic spurs air travel to return to previous levels and growth rates, longer term titanium demand could provide support for vanadium prices.

The energy storage sector is another potential area for growth in vanadium demand. While the demand for vanadium redox flow batteries have not yet seen massive growth, Growth estimates vary wildly, from Roskill's 13% per annum growth to Bushveld Mineral's "aggressive

¹⁷³ Vanadium pentoxide flake 98% purity, China price. Vanadiumprice.com.

¹⁷⁴ Steel Demand Beyond 2030: Forecast Scenarios. Presented to OECD, Paris, September 28, 2017. Available at https://www.oecd.org/industry/ind/Item_4b_Accenture_Timothy_van_Audenaerde.pdf

¹⁷⁵ 7th Vanitec Energy Storage Meeting, June 29, 2020. <http://www.vanitec.org/vanadium/ESC-Meetings>

¹⁷⁶ Information presented to U.S. Government Titanium Sponge Working Group

¹⁷⁷ Fior Markets Titanium Alloys Markets, Published May 2019; Research and Markets Titanium Alloys And Ultrafine Titanium Dioxide Global Market Opportunities And Strategies To 2023, May 2019; Titanium USA 2018 Conference, October 7-10, 2018.

forecast” of 42% annual growth.¹⁷⁸ The relatively conservative Roskill estimate would account for added demand by 2027 of 5,000 tons of vanadium, while Bushveld’s forecast would have vanadium redox flow battery demand increasing by 93,000 tons by 2027, exceeding 2017 total vanadium production.

4. Significant Price Swings Impair the Ability of Domestic Producers to Plan and Carry Out Capital Expenditures

The historic volatility of vanadium prices make it difficult for producers to plan and follow through on investments in new capabilities. Although many industry projects take four or more years to complete, it is likely that vanadium market conditions and prices will change significantly between the beginning and the end of a project, impacting the project’s viability and access to financing.

For example, when Gulf filed for bankruptcy in June 2016, vanadium pentoxide prices had recent lows of \$3 per pound. At the time of Gladioux’s purchase of Gulf’s facility, prices had risen to close to \$6 per pound. While Gladioux has been updating the facility, prices have spiked to \$30 per pound in November 2018, but fell back to \$6 a year later. [TEXT REDACTED]

The most advanced primary vanadium exploration project underway in the United States has had a similar experience. Nevada Vanadium completed the PEA for the Gibellini project in June 2018, when vanadium pentoxide prices were \$15 per pound. The PEA used a forecast price of \$12.73, and reflects a 14-year breakeven price of \$7.76 per pound.¹⁷⁹ With current prices below the breakeven level and an estimated [TEXT REDACTED] required to construct and open the mine, completion of the project may be postponed or cancelled unless vanadium prices have risen before the expected BLM permit decision in August 2021. [TEXT REDACTED]

¹⁷⁸ Bushveld Minerals, Energy Storage & Vanadium Redox Flow Batteries 101. November 13, 2018. <http://www.bushveldminerals.com/wp-content/uploads/2018/11/Energy-Storage-Vanadium-Redox-Flow-Batteries-101.pdf>

¹⁷⁹ https://www.silverelef.com/files/Gibellini_2018_PEA_Technical_Report.pdf

Similar price challenges exist at other domestic mining projects, with limited investment expected absent a rise in vanadium prices. [TEXT REDACTED] In summary, while significant domestic resources of vanadium exist, the long project lead times and volatile vanadium prices often create challenges in obtaining the investments necessary to bring the projects to completion.

E. Unilaterally Increasing Domestic Prices of Vanadium Would Harm Critical U.S. Industries

1. Domestic Vanadium Prices Significantly Exceeding World Prices Would Disadvantage the U.S. Steel Industry

Imports of steel products are currently subject to adjustment based on the finding of a threat to national security in the Secretary's 2018 Steel Report. That report found that the domestic steel industry was threatened by low-cost imports and recommended enhancing the industry's viability through the imposition of tariffs. In imposing a 25% tariff on imports, the President also authorized the creation of an exclusions process, whereby companies could request an exclusion from the tariff. Since the start of the exclusions process in March 2018, more than 250,000 requests for exclusion from the steel tariff have been filed, reflecting significant interest in avoiding additional costs related to the domestic sale of steel products.

With annual production in the U.S. worth \$92 billion, the estimated \$300 million in vanadium demand attributable to the steel industry represents less than 1% of total cost. However, in an industry with small profit margins and under threat from low-cost imports, additional costs for U.S. companies that foreign companies do not bear can be determinative on the company's survival.

While not all steel products contain vanadium, some parts of the steel industry require it. Analysis of exclusion request data showed that 24% of the requests for exclusion from the

Section 232 steel tariff involved a product with at least some vanadium, and 9% of requests required at least 1% vanadium.

Vanadium accounts for a significant percentage of the cost of the steel products in which it is an ingredient, with the result that small changes in the price of vanadium can have a major effect on the overall steel product cost. The cost per ton of vanadium is some 20 to 30 times that of steel products, meaning a 50% rise in vanadium prices would result in a more than 1% increase in the cost of rebar with 0.1% vanadium by weight.¹⁸⁰ For products such as high speed steel with significantly higher vanadium content, the impact can be significantly higher. In an industry such as the steel industry that is already threatened by low-cost imports, imposing additional costs could have a major impact. An increase in the domestic cost of vanadium, while beneficial in the short term to the domestic vanadium industry, would be harmful to the steel industry and encourage the import of steel products that contain vanadium, to the detriment of both the domestic steel and vanadium industries.

2. Domestic Vanadium Prices Significantly Exceeding World Prices Would Harm the U.S. Titanium Industry, to the Benefit of Russian and Chinese Titanium Producers

Although the titanium industry uses far less vanadium than the steel industry, it is much more dependent on vanadium. For most steel uses of vanadium, substitution of niobium or molybdenum is possible, but vanadium is essential to most aerospace applications using titanium. The most common titanium alloy, Ti-6Al-4V, contains 4% vanadium by weight, but represents between 12 and 14% by cost. Further, nearly all vanadium-containing titanium products are used in the aerospace and military sectors, both essential to national security.

¹⁸⁰ Average 2016-2019 vanadium pentoxide prices of \$9.80 per pound, equivalent to \$21,560 per ton. Rebar cost estimated at \$1000 per ton

Titanium, like vanadium and steel, is critical to national security, and was also subject to a Section 232 investigation, based on imports of titanium sponge. One significant concern for the titanium industry is the expansion of low-cost, vertically integrated Russian and Chinese titanium producers. One of the findings of the titanium sponge investigation was that increases in the Chinese and Russian premium quality sponge production threatens the viability of domestic U.S. titanium suppliers to the aerospace industry. The report found that Chinese and Russian sponge producers, underwritten by government support, have or are moving toward creating vertically integrated titanium supply chains that undercut U.S. producers. Because it is able to provide the necessary quality of titanium at lower prices than U.S. producers, Russian titanium producer VSMPO-Avisma provides 35% of Boeing's titanium products, and 50% of Airbus's titanium products.

The threat to U.S. titanium producers from low-cost imports has increased since the titanium sponge investigation ended, as a result of the impact that COVID-19 has had on global titanium demand. Titanium shipments fell [TEXT REDACTED] from 2019 to 2020. Further, demand [TEXT REDACTED]. As a result of these factors, the U.S. titanium industry is facing severe hardship, and any product cost increases in the United States will likely to further disadvantage the industry relative to Chinese and Russian suppliers.

VIII. Conclusion

A. Determination

Based on the findings in this Report, the Secretary concludes that the present quantities and circumstance of vanadium imports do not threaten to impair the national security as defined in Section 232. Although vanadium is critical to national security and the United States is dependent on imported sources of vanadium, several significant factors, including the health of the U.S. industry, the availability of idle domestic resources, ongoing USG actions, and the

importance of vanadium to maintaining competitive steel and titanium industries, indicate that imports of vanadium do not threaten to impair national security.

The United States is reliant on imports to satisfy demand for vanadium products and is not producing significant amounts of vanadium from U.S.-origin material, but these conditions are not expected to deteriorate further. A number of U.S. vanadium producers are increasing their production capacity and/or modernizing currently idled facilities and mines. These initiatives will improve domestic capabilities specific to ferrovanadium and vanadium pentoxide, as well as in primary production. Even if primary production is not feasible at current vanadium prices, the availability of the resources allows for production potential in the event of national emergency. The increased availability of domestic primary vanadium, expansion of secondary production, and addition of domestic feedstock for secondary production should mitigate current abnormal levels of reliance in imports.

However, the Department recognizes that rising capacity does not necessarily mean the domestic vanadium industry is healthy. In addition to the long history of volatility of vanadium prices, the main users of vanadium—the steel and titanium industries—experienced major declines in demand in 2020 as a result of COVID-19, with the titanium industry particularly challenged due to its reliance on aerospace demand. If vanadium prices fail to rise, some of the capacity under development or exploration may not turn into production, and one or more secondary producers is likely face financial difficulty or challenges in sourcing affordable vanadium-bearing feedstock.

Further, the Department's lack of a finding of an immediate threat to national security does not indicate that a healthy domestic vanadium industry is not of vital importance to the United States. While the Secretary does not believe that imports of vanadium need to be adjusted at this time, there are steps that should be taken to support the domestic vanadium industry and

related sectors, to ensure safe and reliable sources of vanadium in the event of a national emergency and to enhance and protect U.S. national security.

B. Recommendations

The Department has identified several actions that would help to ensure reliable domestic sources of vanadium and lessen the potential for imports to threaten national security. These actions are not intended to be exhaustive or exclusive; the Secretary recommends pursuing all proposed actions.

Recommendation 1 – Expansion of the National Defense Stockpile to Include High Purity Vanadium Pentoxide

The USG should support domestic vanadium production and ensure a source of vanadium in the event of national emergency by re-adding vanadium pentoxide to the National Defense Stockpile. Vanadium pentoxide was part of the stockpile until 1997; the stockpile held 6,200 tons of contained vanadium¹⁸¹ in 1965 and had a goal of 7,000 tons though it held just 651 tons prior to the decision to reduce the target level to zero in 1993, following the end of the cold war.¹⁸² Using high purity vanadium pentoxide—suitable for use in titanium alloys or chemical uses as well as conversion into ferrovanadium for use in the steel industry—would ensure vanadium held in the stockpile could be used for any necessary product in the event of national security.

National Defense Stockpile goals were initially set to ensure sufficient product to support one year's demand for the entire country but were later narrowed to focus on defense-specific needs, primarily due to funding constraints. Given the importance of vanadium and other critical minerals to the economy, the economic and national security of the United States would be better served by pursuing stockpile goals that support national security beyond defense-specific

¹⁸¹ Vanadium is generally reported in terms of “contained vanadium”, or the weight of only the vanadium portion of a vanadium compound. Vanadium represents 56% of the weight of vanadium pentoxide.

¹⁸² USGS Vanadium Mineral Commodity Summaries. <https://www.usgs.gov/centers/nmic/vanadium-statistics-and-information>

requirements. The re-addition of vanadium to the stockpile would require authorization and funding from Congress.

The Department recommends that the size of the proposed vanadium addition to the stockpile should be based on three benchmarks: defense system requirements, broader national security requirements, and total domestic demand. As discussed above, defense system requirements may conservatively amount to 273 metric tons of vanadium content per year; this inventory level would be worth approximately \$10.5 million based on average vanadium pentoxide prices since 2016.¹⁸³ Critical infrastructure requirements add an estimated 4,527 tons per year, resulting in a minimum stockpile goal based on total national security requirements of 4,800 tons of contained vanadium, at a cost of \$184.8 million. Finally, total domestic apparent consumption (including defense and critical infrastructure needs) averaged 8,590 tons of contained vanadium annually from 2016 to 2019. Establishing a stockpile goal at this level, sufficient to meet all domestic demand would, would be valued at \$330.6 million.

Beyond the minimum stockpile level, the Secretary further recommends that the stockpile of vanadium pentoxide be authorized to expand in size during periods of unusually low prices (with purchases made from domestic producers), while remaining unchanged or shrinking during periods of higher-than-average prices. This policy would help mitigate the large historic price swings that have caused significant financial distress and impeded capital investment in the domestic vanadium industry while helping to regulate domestic prices.

Implementing this policy would require legislative changes to the Strategic and Critical Materials Stockpiling Act (50 U.S.C. §98, et seq.) (Stockpiling Act). While the mitigation of critical mineral price swings and the purchase of critical minerals from domestic producers at a premium when prices are unusually low serves the interest of national defense, the Stockpiling Act requires that the stockpile “not be used for economic or budgetary purposes,” which may

¹⁸³ Average price per pound vanadium pentoxide from 2016-2019 of \$9.80, based on data from USGS: <https://pubs.usgs.gov/periodicals/mcs2020/mcs2020-vanadium.pdf>

present a challenge in allowing the stockpile to exceed minimum defense needs based on prices. Allowing the stockpile to be used for economic purposes if such actions support the health and competitiveness of affected industries would help enhance U.S. national security.

As an additional potential benefit, once the vanadium holdings in the National Defense Stockpile are established, they could—with the authorization of Congress and in cooperation with the Department of Energy—be used without cost to support another sector: large scale energy storage. As noted above, a potential new use for vanadium is in vanadium redox flow batteries, which have the advantage of using vanadium in both parts of the electrolyte, eliminating the risk of cross-contamination and allowing for the vanadium to be re-claimed from the batteries at a low cost with minimal yield loss¹⁸⁴.

With vanadium accounting for approximately 30% of the cost of a vanadium redox flow battery and initial battery cost reductions needed to enable larger scale use, the USG could reduce the costs of the stockpile and support the energy storage sector by leasing a portion of the stockpile to be managed by vanadium redox flow battery companies, on condition of the leased vanadium being immediately reclaimable in the event of a national emergency. Given restrictions on transfers to and from the stockpile, this use of material in the stockpile would require either a legislative change to the Stockpiling Act or the designation of the leased material as still being part of the stockpile despite being used for energy storage.

Recommendation 2 – Recycling Promotion

The Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals (Federal Strategy) identifies an available, on-demand supply of critical minerals as “essential to the economic prosperity and national defense of the United States.”¹⁸⁵ The Federal Strategy recommends the support of recycling and reprocessing of critical minerals, including vanadium.

¹⁸⁴ Vanitec estimates cost of conversion from leachate to vanadium pentoxide at \$1 per pound vanadium pentoxide with a 95% yield. <http://www.vanitec.org/vanadium/ESC-Meetings>

¹⁸⁵ https://www.commerce.gov/sites/default/files/2020-01/Critical_Minerals_Strategy_Final.pdf

Given that nearly all vanadium production in the United States is performed through recycling, the USG should support the vanadium industry through USG-wide actions to promote the recycling of materials containing critical minerals.

A 2002 EPA analysis, carried out in support of the May 8, 2002 final rule on the identification and listing of spent catalysts as hazardous waste, showed that in 1999, just 55% of spent catalyst was recycled, in large part because the cost of recycling was estimated to be three times that of landfill disposal.¹⁸⁶ Bringing the recycling of vanadium-bearing wastes generated in the United States to or near 100% has the potential to greatly expand the availability of vanadium products of domestic origin. Such recycling will occur naturally with higher vanadium prices, as refiners typically receive a metals credit from vanadium producers based on vanadium sale price, but can also be encouraged through the consideration of recycling tax deductions or credits as well as EPA review of their regulatory authority governing disposal of hazardous waste.

For example, additional information submitted by industry to the Department reported that the 2020 International Maritime Organization's (IMO) regulation requiring the reduction of allowable levels of sulfur in maritime fuels from 3.5% to 0.5% has increased refinery catalyst use, which is expected to result in increased availability of spent catalyst used to produce vanadium.¹⁸⁷ Similar regulations in the United States would support both the EPA mission to protect human health and the environment and domestic production of critical minerals.

Recommendation 3 – Continue USG Actions to Support Critical Minerals

Many of the challenges domestic vanadium producers face are not unique to vanadium; with this investigation the Department has completed Section 232 investigations on four of the 35 critical minerals. While the specific challenges of each critical mineral are distinct, many industrial trends are similar and broad solutions may be more effective than individual targeting.

¹⁸⁶ 67 FR 30811 and <https://archive.epa.gov/epawaste/hazard/web/pdf/backdoc.pdf>

¹⁸⁷ <https://ig9welq348z124x3t10meupc-wpengine.netdna-ssl.com/wp-content/uploads/AMG-Annual-Report-Web-FINAL.pdf>

There are several ongoing and proposed U.S. government actions that support the domestic supply of critical minerals. Continuing to pursue these actions will provide necessary support to the domestic vanadium industry as well as to the broader critical minerals sector.

Among the key actions that will enable strong domestic critical minerals industries are Executive Order 13817 and the resulting Federal Strategy, Executive Order 13953 (*Addressing the Threat to the Domestic Supply Chain From Reliance on Critical Minerals From Foreign Adversaries and Supporting the Domestic Mining and Processing Industries*), proposals from the USG Nuclear Fuel Working Group, work being carried out by the Titanium Sponge Working Group, and legislative action to support domestic production of critical minerals. Since the list of suitable substitutions for vanadium in steel and certain chemical processes includes other minerals on the critical minerals list (including manganese, niobium, titanium, tungsten, and platinum), actions to support production of critical minerals as a whole would also help to address domestic vanadium supply challenges.

The Federal Strategy, developed pursuant to Executive Order 13817, was announced in June 2019, with six calls to action containing 24 goals and 61 recommended actions that federal agencies should pursue to improve the availability of critical minerals and their downstream supply chains in the United States to help reduce the country's vulnerability to supply chain disruptions. Many of the identified goals of the Federal Strategy are consistent with the findings and recommendations of this investigation, including:

- (a) support for downstream materials production capacity;
- (b) enhancing the National Defense Stockpile's ability to meet military as well as civilian requirements;
- (c) securing access to critical minerals through trade and investment with allies;
- (d) identifying methods to encourage secondary use of critical minerals; and
- (e) streamlining permit processes for critical mineral projects

The President issued Executive Order 13953, “Addressing the Threat to the Domestic Supply Chain From Reliance on Critical Minerals From Foreign Adversaries and Supporting the Domestic Mining and Processing Industries,” (E.O. 13953), in September 2020. The Order identifies the need to ensure a consistent supply of critical minerals and declares a national emergency to reduce the threat posed by the country’s undue reliance on critical minerals from foreign adversaries. Many of the actions taken pursuant to E.O. 13953 will support the domestic vanadium industry, particularly vanadium mining.

In addition to Executive actions, there have recently been several legislative proposals that would provide support for vanadium and other critical minerals. Examples include H.R. 8143 (also known as the Reclaiming American Rare Earths (RARE) Act) and S. 3694 (the Onshoring Rare Earths (ORE) Act of 2020). Both bills as written restrict the definition of critical minerals to a subset of those identified by the Department of Interior in response to E.O. 13817, and need to be expanded to include vanadium and other critical minerals, but otherwise have features of significant value to the domestic vanadium industry. In addition to allowing a tax deduction for investments in property used for mining, reclaiming, or recycling critical materials, these bills would support the function of critical minerals in the broader economy by providing grants or allowing tax deductions for critical minerals extracted in the United States. In addition to expanding the bills to include vanadium (as noted above), in order to provide the most value to the country, the Department recommends that any legislation should ensure that extraction incentives include recycling and reclamation.

Finally, the Department’s Section 232 investigations into imports of Uranium and Titanium sponge resulted in the creation of USG working groups tasked with developing recommendations additional to those made in each report. Given the significant intersections between the vanadium industry and the uranium and titanium industries, the implementation of the working groups’ recommendations will support the vanadium industry as well.

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